ARIZONA DEPARTMENT OF TRANSPORTATION

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IDENTIFYING AND IMPLEMENTING CORRIDOR SAFETY IMPROVEMENTS

A Highway Safety Improvement Process and Safety Analysis Tools for Arizona

Final Report

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16. Abstract

Arizona Department of Transportation (ADOT) recognizes that evaluation of highway safety from a corridor perspective provides different benefits than the spot analysis used up until now. The project programming procedure at ADOT accepts a quantitative ranking of safety considerations for each potential project in assessing a project's benefit. ADOT highway safety engineers are in need of spatial tools that analyze the crash database, providing spot analysis, corridor analysis, and the quantitative output desired by transportation planners.

FHWA has endorsed the Corridor Safety Improvement Program (CSIP) process as a methodology for gathering multi-disciplinary input from enforcement, education, and emergency medical services (EMS) personnel to supplement the engineering point-of-view and arrive at better decisions from a multi-objective perspective. NHTSA has a Safe Communities Initiative, which promotes the same type of multi-disciplinary safety team (MDST) concept towards improving safety in communities (as opposed to corridors). This paper explores Arizona's ability to adopt the FHWA CSIP model and adapt it to work within the institutional, jurisdictional, resource, and funding framework of Arizona.

The results of the project indicate that:

- ADOT is only one of several state agencies that have a hand in promoting and providing highway safety.
- All agencies that endeavor to improve highway safety should collaborate and focus on high-risk corridors to effectively develop multi-objective action plans and implement the most appropriate countermeasures.
- The identification of high risk spots and corridors can be greatly assisted using contemporary GIS spatial analysis tools and the Accident Location Identification Surveillance System (ALISS) crash database.
- The ADOT photo log and GPS-derived corridor centerline files add a unique level of comprehension of safety problems by showing signing/striping/guardrail conditions in plan and profile views overlain with the ALISS crash history and a link to a photo log image of the roadway.

Pilot study and workshop participants agreed that Arizona corridors and communities would benefit from the prototype GIS tools and a CSIP process, as have several other states. The advent of a new highway bill (TEA-21) will bring more safety-related funding to Arizona, making it important to resolve institutional issues between agencies. Prototype tools should be developed to fruition so participants in all Arizona agencies can be trained in contemporary methods of identifying high-risk corridors or spots. A steering committee should be formed to establish a position for a CSIP Coordinator and oversee the selection of corridors and the program in general.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.452	centimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3.

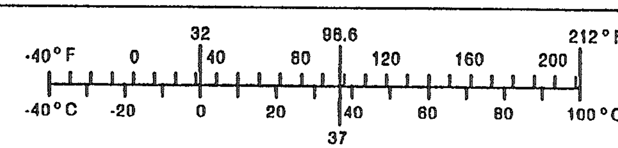
Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	millimeters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1 INTRODUCTION

In the early 1990s a national Corridor Safety Improvement Program (CSIP) introduced a multi-disciplinary approach to highway safety improvement evaluation. The program was jointly launched by the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA). Some states incorporated federal CSIP guidelines into their existing safety programs, while others initiated new corridor safety programs fashioned along the federal guidelines. A review of ADOT efforts in establishing a Safety Management System for Arizona revealed that in 1995 a Corridor Safety Improvement Program was the leading priority for the Safety Management System that evolved from federal transportation legislation in 1991.

As a result of these early findings, the study team proposed a similar multi-disciplinary, multi-agency approach for corridor safety improvements in Arizona. This approach broadened the research into a truly comprehensive study of how to implement corridor safety improvements.

The multi-disciplinary approach to corridor safety improvements also revealed that ADOT is not (and should not be) the single responsible stakeholder for improving highway safety. The new approach requires the participation of a number of other stakeholders in the state. Such broadening of the responsibility is often perceived as difficult and risky, particularly due to institutional barriers. Regardless of the difficulties that lay ahead, the study approach was aimed at improving the state-of-the-practice in highway safety in Arizona.

The vision, leadership, and institutional cooperation of key stakeholder agencies are factors that will affect the timely implementation of a program of this nature. Mishaps, injuries, and fatalities will continue to be addressed by the existing patchwork of efforts. However, a Corridor Safety Improvement Program process that combines these efforts and methodically collaborates to minimize these problems should improve safety.

1.1 GOALS AND OBJECTIVES

The primary goal of this study is to develop systematic procedures for identifying and implementing corridor safety improvements. The following objectives were identified for ensuring that the product of this research will lead to improvement of existing state-of-the-practice as well as eventual full-scale implementation:

- Identify the future role of accident and road safety databases in providing input to the priority programming process.
- Identify datasets and tools that are needed to evaluate highway corridors for safety-related improvements.
- Identify procedures that would comprise a corridor safety improvement program in Arizona.
- Identify an implementation plan for delivering the CSIP program to Arizona.

The research efforts concentrated on the following two areas of study:

- Develop useful analysis tools that can be readily used by agencies participating in future corridor safety projects.
- Conduct a pilot study to help identify and develop the procedures suitable to Arizona stakeholders.

In addition to the study objectives stated above, it became evident that the following factors need to be addressed in order to advance the odds of implementation:

- Educate and inform the highest people in key stakeholder agencies on the value of a CSIP for Arizona
- Identify a lead CSIP agency

1.2 REPORT CONTENT AND ORGANIZATION

It is the intent of this report to provide the reader with an understanding of the state-of-the-practice in highway safety improvement methodology, an update on related initiatives and activities in the nation, a summary of activities on this study, and the resulting implementation plan.

In addition to documenting the research study approach and outcome, this report is intended to be the penultimate CSIP reference document for highway safety proponents in Arizona. Towards this objective, an effort has been made to include relevant material in this report that would be useful for the agency that will champion a future CSIP in Arizona.

2 HIGHWAY SAFETY IMPROVEMENTS IN ARIZONA

Programs and projects that are particularly targeted towards identifying and implementing highway safety improvements in Arizona are carried out by the following entities:

- Arizona Department of Transportation (ADOT)
- Arizona Department of Public Safety (DPS)
- Governor's Office of Highway Safety (GOHS)
- Local communities, metropolitan planning organizations (MPOs) and councils of government (COGs)
- Department of Health Services (DHS)

The focus of ADOT in identifying hazardous spot locations and making highway safety improvements has been the CLOSE (Candidate Locations for Operations and Safety Evaluations) program. A discussion on the CLOSE program is provided in Section 2.2. This program has long been supported by crash data in the Accident Location Identification Surveillance System (ALISS) maintained by ADOT. The ALISS program is described in Section 2.1.

The Arizona DPS carries the responsibility of patrolling Arizona's highways and reporting and investigating the crashes that occur. The DPS is also involved in educational and special enforcement campaigns funded by GOHS.

The GOHS supports community and local highway safety programs and is funded by Section 402 funds, a majority of which is from National Highway and Traffic Safety Administration (NHTSA). The GOHS and its role in highway safety are described in Section 2.3.

Local communities, MPOs, and COGs use tabular ALISS data **and** locally collected data to identify highway safety problems and program improvements on roadways off of the State Highway System. Hence, ALISS database is a resource in other efforts.

The Department of Health Services (DHS) is heavily involved in a number of activities that are related to injury prevention and emergency medical services. Therefore, this agency is a primary stakeholder agency in any safety improvement program in the state. Office of Emergency Medical Services (OEMS) is the lead agency responsible for EMS in Arizona. DHS has also implemented a statewide trauma registry in every trauma center in the state and a statewide hospital discharge system has also been implemented. The national project, Crash Outcome Data Evaluation System (CODES), will establish data links between crash and hospital records. Arizona has applied to become a CODES state and if selected DHS will play an even larger role in helping identify the true societal costs of crashes.

2.1 HISTORY AND CURRENT STATUS OF ALISS DATABASE

The Traffic Studies Group maintain the ALISS database tables by compiling standardized reports from the local government agencies. By statutory requirement, motor vehicle crashes involving fatalities, injuries, or property damage in excess of $500 are reported to ADOT by law enforcement agencies. The Tribal Nations are not covered by this requirement, hence crashes that occur within tribal jurisdictions are not reported in the ALISS database. Approximately 115,000 accident reports are entered into the ALISS database each year, with the bulk of that data (80 percent or more) generated from metropolitan areas. The ALISS database contains information on the previous five years and the current year. The only sources of information on other types of crashes (e.g., pedestrians with bicycles or minor property damage) are insurance databases or hospital discharge and/or trauma registry data.

The ALISS relational database resided in a mainframe computer at ADOT since 1975. From the beginning, it was a spatial database supported by a link-node electronic map of digitized roadway centerlines representing the entire state of Arizona. The data tables within ALISS migrated to a Sybase® environment in about 1994. At the same time the map components (i.e., link-node map and reference markers) migrated into a contemporary geographic information system (GIS) environment in Arc/Info®, where these coverages are now called Arizona Transportation Information System (ATIS) Roads and ATIS Markers.

Prior to this research, a pilot geocoding study followed by a complete geocoding effort re-married the ALISS database tables to the GIS coverages.[1] As a result, 80 percent of crash locations for the years 1991 to mid-1996 have been geocoded with full confidence (i.e., highest accuracy).[2] In January the ALISS database server was equipped with prototype software that provides for the continual geocoding of new crash records on a user-requested basis.

The ALISS tables migrated from Sybase® to a Microsoft SQL Server® environment in about 1997. The original mainframe programming that performed non-spatial queries and generated non-spatial reports on ALISS tables was finally upgraded in 1997 using ADOT's Information Access (INFACCS) software programmed by MICON, Inc., making approximately 60% of the original IBM reporting capability available to safety analysts.

The remaining approximate 40% of the reporting supported the CLOSE program. It required spatial analysis and was not migrated, pending the subsequent direction and funding once the ALISS re-marriage to ATIS was complete. So prior to this research, there was no simple way to generate a *comprehensive* list of hazardous locations by area. The implementation of updated CLOSE functions is currently awaiting the new contemporary tools that this research may offer to the many end users of the ALISS database.

2.2 ROLE OF CLOSE PROGRAM

The mission of the Candidate Locations for Operations and Safety Evaluations (CLOSE) program is to reduce the frequency and severity of traffic accidents on the non-interstate State Highway System through the development of Hazard Elimination Safety (HES) projects.[3]

The goals and tasks to achieve that mission have been identified by ADOT in the above reference. In reference to this research, the CLOSE program uses the ALISS database to locate spot areas of high accident frequency or severity (i.e., identification) and systematically promotes construction projects (i.e., implementation) aimed to reduce the identified hazards. The CLOSE program also prepares before and after studies (or research) to measure effectiveness of these projects. Therefore, the CLOSE program can arguably be considered ADOT's existing "engineering" component of a corridor safety improvement program (CSIP).

The method of identifying high accident locations by the CLOSE program using the ALISS database is as follows:

1. For each type of highway the program first determines the length of a *slide*, which essentially is a length of a highway window. The length of this window is inversely proportional to the traffic volume carried by the highway at a particular location. Highways that carry higher traffic volumes will result in smaller slide lengths. This adjustment acts as a normalization for the type of highway and the traffic volumes carried.

2. The *window* is then moved down the highway in increments. An algorithm tallies the crash frequency at each increment. The statewide mean and variance for the accident rate is computed based on this data.

3. The final step in identifying hazardous locations involves the identification of slide locations that produced an accident frequency exceeding three standard deviations (99.73 % confidence level) above the statewide mean. The resulting locations are put on the high priority list.

Each year the ADOT Safety Team reviews 75 different locations. Funds available for safety improvement projects are applied to as many of these sites as possible.

2.3 ROLE OF GOVERNOR'S OFFICE OF HIGHWAY SAFETY

The GOHS is the state agency that is responsible for promoting highway safety. GOHS has control over both NHTSA and FHWA portions of federal funds dedicated to highway safety. These funds support programs managed by the GOHS in the areas of enforcement, education, and community-based programs. The GOHS utilizes data from ALISS provided by ADOT to examine the crash experience in Arizona. Each fiscal year, GOHS files the State's application for Section 402 funds with NHTSA for its highway safety program. According to Interim Rules for the State Highway Safety Plan announced by NHTSA early in 1997, future-funding applications will require the following components:[4]

1. A Performance Plan that contains:
   - A list of measurable highway safety goals. Each goal must be accompanied by at least one performance measure that will enable the State to track progress from a specific baseline towards meeting the goal.
   - A brief description of the process used by the State to identify its highway safety problems, define highway safety goals and performance measures, and develop projects and activities to address its problems and achieve its goals.

2. A Highway Safety Plan, approved by the GOHS, describing project activities the State plans to implement to reach the goals identified in the Performance Plan. The Highway Safety Plan must describe at least one year of activity.

3. A certification statement signed by the Governor's representative for Highway Safety.

4. A Program Cost Summary that reflects the State's proposed allocations of funds by program area, based on goals identified in the Performance Plan and activities in the Highway Safety Plan.

It is important to understand that recent GOHS-supported projects in Arizona are directed towards education, enforcement, and emergency medical services primarily. GOHS supported the collection of crash data in the ALISS database back in the early 1990s, as the ALISS file is instrumental in the preparation of GOHS reports. ADOT has not been the recipient of any GOHS grants since then.

3 SAFETY MANAGEMENT SYSTEM

The ADOT Safety Management System (SMS) is herein presented in several parts. First, Intermodal Surface Transportation Equity Act of 1991 (ISTEA) and SMS are defined. Then the ADOT vision for SMS and overall goals are presented. Next, historical, on-going, and planned activities within ADOT that may impact the SMS are outlined. Finally, a description of the SMS and its potential role in this study is presented.

3.1 ISTEA AND SAFETY MANAGEMENT SYSTEMS

The ISTEA mandated that all state DOTs implement six management systems comprising highway pavement, bridge, highway safety, traffic congestion, public transportation facilities/equipment, and intermodal transportation facilities/systems. This legislation encouraged the states to establish a systematic basis for managing transportation infrastructure. The legislation also specified compliance deadlines and sanctions for non-compliance.

Many state DOTs took steps towards implementing these systems using existing systems and functions related to the objectives of these systems. While the goals of these management systems were certainly achievable if sufficient resources were available to implement and operate them, many agencies found the task of implementing them within the stipulated time frame a daunting task. Subsequent feedback to the US Department of Transportation (USDOT) resulted in these management systems being made optional (except for the congestion management systems in certain areas) through a modification to ISTEA introduced as part of the National Highway System Designation Act of 1995.

A General Accounting Office report dated February 1997 reports that with the exception of Ohio and South Carolina, all other states as well as the District of Columbia and Puerto Rico are continuing to develop these systems.[5] In these states, the implementation of safety management systems varies. Some systems are administrative structures composed of a coordinating or executive committee and subcommittees consisting of members representing many agencies. Others are large database systems that merge safety information from a number of sources along with analytical tools.

3.2 DEFINITION OF A SAFETY MANAGEMENT SYSTEM

SMS is defined as a systematic process designed to assist decision makers in selecting cost-effective strategies and actions that would improve efficiency, safety and preserve transportation infrastructure. The key functions of a SMS are:

- Identification of performance measures.
- Integration of data collection and analysis.
- Identification of needs.
- Evaluation and selection of appropriate strategies and actions to address the needs.
- Evaluation of the effectiveness of the implemented strategies and actions.

A recent USDOT publication on Case Studies of Highway Safety Management Systems states there is no one correct way to build a SMS.[6] An effective SMS is identified as one that meets the needs of the particular state. The study further recommends that states may want to use the SMS as a mechanism for:

- Seeking advice and input from a diverse group.
- Developing multi-disciplinary initiatives.
- Coordinating/integrating decisions that cut across other management system boundaries.

3.3 ADOT'S VISION FOR SMS

The ISTEA Status Report for the week of May 8, 1995 summarized a vision of expanding the capabilities of SMS to include the following functions beyond the CLOSE program:[7]

- **Establish a Corridor Program** - This program would give ADOT the ability to address safety improvements along whole transportation corridors. It would be based on interagency coordination with the involvement of representatives on engineering, enforcement, emergency response, and community education issues. A committee would be formed to look at high accident frequency corridors.
- **Study Intersection-Related Accidents** - The CLOSE program deals only with roadway segments and cannot explore the relative magnitude of intersection accidents. The ability to examine intersection accidents would enable the SMS to identify high-risk intersections and perhaps identify an appropriate set of countermeasures.
- **Sharing of Information** – ADOT's Traffic Studies Group would like the ability to share safety related information with the GOHS, Maricopa Association of Governments (MAG), Pima Association of Governments (PAG), and cities. The group would also like to obtain safety-related information available at other ADOT sources, such as the photolog of the State Highway System maintained by the Data Team in the Transportation Planning Group.
- **Ability to Access Crash Data More Efficiently** - When safety projects are implemented as part of the hazard elimination program, the Traffic Studies Group conducts before-and-after analyses. These analyses require at least 3 years of

previous and subsequent data. At present this is done manually for each project. Implementation of the SMS in a geographic information system would enable increased automation of this effort.

Consultations with the State Traffic Engineer and the Traffic Studies Group (October 1997) indicated that the ability to study intersection-related accidents is currently the highest priority.

3.4 ADOT'S SMS COMPONENTS

In 1995, ADOT's SMS information was summarized as comprising six specialized databases:[8]

- Accident Location Identification and Surveillance System (ALISS)
- Highway Performance Monitoring System (HPMS)
- Emergency Medical Services (EMS) Trauma Database
- Judicial Database
- Fatal Accident Reporting System (FARS)
- Project Enterprise (to provide the link to Driver and Vehicle files)

ADOT Traffic Studies Group uses the ALISS, HPMS, and FARS databases when assessing and projecting the State's safety needs. The EMS Trauma and Judicial databases were planned by other agencies and are not available at present. The ADOT Motor Vehicle Division's Enterprise Project, now terminated, once planned to link driver license and vehicle registration files. This is no longer an agency priority.

3.5 SMS HISTORICAL ISSUES

The ISTEA Status Report raised some issues that deserve mention:[9]

- **Safety Management System Pilot Project** - The ISTEA Status Report makes reference to a proposed SMS Pilot Project and a number of benefits that may accrue from such a pilot. Review of past SMS related ADOT efforts revealed that this pilot project had not been initiated.
- **Overall SMS Conceptual Model** - Based upon various reviewed literature, there is an apparent need to develop an overall conceptual model for an SMS. This is a component that could not be located in our ADOT research effort. Such a model will define the role and function of each SMS component and its relationship to the overall goals and objectives of the SMS.
- **Plan for Capturing Information Outside of ALISS** - The SMS functions envisioned by ADOT require the capture of data from sources outside of ALISS (e.g.,

judicial, Enterprise-type, and EMS databases). This need to capture such data has not yet been addressed. A national project funded by NHTSA is helping states coordinate crash data with EMS data. The Crash Outcome Data Evaluation System (CODES) project has 15 participating states at present. In April 1998, the University of Arizona Health Sciences Center submitted an application to participate in the CODES project.

3.6 STATUS OF ARIZONA SMS IMPLEMENTATION

The SMS at ADOT has gone through steps aimed at delivering the ALISS database to multiple ADOT desktops via a client-server environment using the Microsoft SQLserver® database engine. A previous attempt to deliver the same information via a Sybase® engine was terminated in 1996, mostly due to high relative maintenance costs of the Unix platform compared to the WindowsNT® platform which the Technology Information Resources (TIR) group was implementing across ADOT.

The arrival of the ALISS database in a SQL environment on desktops at ADOT coupled with the geocoding of ALISS and the delivery of prototype spatial analysis tools, comprise the few significant improvements to the SMS over the course of ISTEA. Currently, many of the anticipated benefits of a SMS could be realized through properly funded implementation, including the following:

- Linking of accident data to related information (e.g., travel volume or feature inventory databases).
- Establishment of spatial corridor and intersection analysis tools.
- Sharing of data with COGs, MPOs, and local governments via CD-ROM.

Prototype software products to illustrate the benefits of comprehensive safety management tools were developed during the course of this research. The migration of these tools to a stable and useful stage of development is discussed in Chapter 11.

4 NATIONAL PROGRAMS ON CORRIDOR & COMMUNITY SAFETY

During the early 1990s, a national CSIP aimed at reducing traffic fatalities and injuries was launched by FHWA and NHTSA. This program targeted highway corridors and communities that were faced with serious road safety issues. It is clear from results to date that such programs have often exceeded their original goals for safety improvements.

Community-based traffic safety programs (CTSPs) have been around since the early 1980s for addressing vehicle and driver issues. Not long after the CSIP got underway NHTSA launched an effort to combine CTSPs and CSIPs. This effort led to the hybrid corridor/community traffic safety program (C/CTSP). This program has evolved into the Safe Communities Initiative launched by NHTSA in 1996.

All these programs have a common goal in that they all promote multi-disciplinary and multi-agency approaches to identifying highway safety problems and countermeasures. Despite the lack of sustained focus and emphasis at the national level, the successes of many state programs can be traced back to the early initiatives.

It is clear that the traditional thinking about the local highway department as being the sole decision maker on local highway safety issues have given way to a more systematic approach. The more progressive states in the nation have learned of the obvious benefits of this approach and have launched safety programs and projects fashioned along this philosophy. These agencies have not only begun reaping the benefits from these programs through lives saved and injuries avoided but are also recognized as being truly responsive to transportation safety issues at the local level. Although there is overwhelming evidence to support comprehensive safety programs, such efforts require working in multi-agency teams and often require compromising age old agency positions on procedures and jurisdiction. These issues are further discussed in Chapter 9. It is evident that states that have been able to launch successful multi-disciplinary and multi-agency highway safety initiatives have first acknowledged that federally mandated highway safety improvement programs are only one part of the solution to a truly comprehensive safety program. They have also realized the ineffectiveness of isolated safety programs run by individual agencies without sufficient coordination with other players.

4.1 CORRIDOR SAFETY IMPROVEMENT PROGRAM

The CSIP approach resulted from an awareness in the transportation community, in the late 1980s, that highway engineering based safety improvements alone are limited in their effectiveness due to driver-, vehicle- or environment-related factors that are beyond the control of highway engineers. Several states began to consider other factors and initiate safety programs designed to expand the traditional approach. The new approach meant bringing in new disciplines such as enforcement officials, public education officials, and emergency medical service personnel to participate in discussions on highway safety improvements.

The Pennsylvania Department of Transportation (PennDOT) lead the nation in this innovative approach and launched a series of safety improvement projects along arterial corridors, using a multi-disciplinary approach to solving safety problems. That effort proved to be very successful and resulted in FHWA and NHTSA adopting the PennDOT program as the foundation for a national Corridor Safety Improvement Program. Guidelines for implementing a CSIP were developed by FHWA and presentations made across the country encouraging local agencies to begin to think "outside the box" about how to identify problems and implement highway safety improvements.

Although no records or reports were found on any CSIP activity in Arizona, an Arizona CSIP was initiated in 1991 for the US-93 corridor from Kingman to the Nevada border. Apparently that effort had very limited success and did not result in any implementation.

The goal of a CSIP is to implement comprehensive and coordinated safety improvements that are targeted at the safety concerns due to driver-, vehicle- and highway- related causative factors. These improvements are implemented on highway corridors with crash and fatality rates substantially higher than similar facilities at other locations.

4.2 SAFE COMMUNITIES INITIATIVE

Safe Communities is an initiative by NHTSA that is very similar in its approach to problem identification to the CSIP approach. A Safe Community is defined as a community that promotes injury prevention activities at the local level to solve local highway and traffic safety and other injury problems.

The Safe Communities approach:

- Emphasizes the importance of analyzing local data, as well as linking crash data with public health, cost and other data to obtain an accurate picture of the injury problem and its effects on the community.
- Transcends the usual traffic safety partners to include public health, medicine, emergency medical services, law enforcement, business, and community organizations in a Safe Community Coalition.
- Places a special emphasis on citizen involvement.
- Incorporates prevention, acute care, and rehabilitation as essential components of an integrated and comprehensive injury control system.

In its approach to improving highway safety, the Safe Communities Initiative is very similar to a Corridor Safety Improvement Program. The emphasis of Safe Communities is more on non-engineering countermeasures.

4.3 EXPERIENCE OF OTHER STATES

PennDOT is credited with being the pioneering agency responsible for introducing a new approach to road safety improvements that required thinking "outside the box". This effort led to the national program. Following the national promotion of CSIPs a number of states initiated programs. The following are the first states to have initiated CSIPs:

Alaska	Kansas	Nebraska	South Carolina
Delaware	Louisiana	New Jersey	Washington
Indiana	Missouri	Oregon	West Virginia
Iowa	Montana	Pennsylvania	Wisconsin

The following is a brief summary of the CSIP procedures followed by these states.

Selection of Candidate Corridors

Indiana:	Identified the corridor with the highest crash rate in the state
Pennsylvania:	Performed field reviews on a number of potential corridors within each state district
Montana:	Selected a corridor with a high representation of elderly driver crashes
Iowa:	Selected a corridor with high commercial traffic where safety is a major concern

Identification of Project Needs

Montana:	A task force compiled a list of engineering, enforcement, EMS, and education countermeasures
W. Virginia:	A local multidisciplinary committee, led by a MPO, developed an action plan
Nebraska:	State Traffic Safety Engineer took lead in identifying corridor needs
Washington:	Multidisciplinary committee for each corridor developed countermeasures; held public forums on draft action plan for corridor projects
Wisconsin:	Held informal meetings with local officials to obtain input and assistance

Implementation

Oregon:	Reduced speed limit, improved intersection sight distance, increased enforcement, adjusted signal timing, installed new signs to encourage drive with headlights on, promoted safety essay contest in schools
Wisconsin:	Improved pavement markings and signs, widened edge lines, increased enforcement; Educational material on route hazards and safe driving behavior
Alaska:	Installed new lighting at intersections and created corridor consistency
W. Virginia:	Provided public service announcements, police overtime, low-cost traffic control improvements
Montana:	Provided public service announcements targeting corridor communities on driving vision, reactions, medication, alcohol and pedestrian safety; provided driver self assessment kits
S. Carolina:	Studied several Interstate projects along CSIP principles
New Jersey:	Adopted CSIP principles in the Highway Safety Improvement Program and Signal Timing Program

Other states that are known to have launched CSIPs or programs with CSIP principles more recently are Virginia, California, and North Carolina.

4.4 RECENT SUCCESSES

The most recent success stories in the area of corridor safety improvements come from California. The program in California started with a $280,000 grant from the California Office of Traffic Safety. The program, administered by the California Highway Patrol (CHP), preceded the implementation of the SMS but served as a good for example for the multidisciplinary approach promoted by a SMS. A summary of one example project follows.

Pacific Coast Highway (State Route 1) Safety Corridor Project

Scope: The Project Task Force identified, discussed, recommended, and implemented short- and long-term actions to improve traffic safety on a 10-mile, two-lane stretch of State Route 1 in northern Monterey County.

Action Plan: The entire action plan is provided in Appendix H.

Implementation: The total project cost was $217,000 of which only $10,000 was spent on contractual services. Most of the funds were spent on recommendations for increased enforcement and public information and educational measures. In addition, Task Force members applied for and secured additional funds to implement solutions for the corridor:

- CalTrans District 7 granted the City of Oxnard a $300,000 STP Safety Set Aside for an intersection improvement

- The Ventura County Transportation Commission and Cellular One provided $350,000 to install call boxes and micro cell sites to allow more rapid response to stranded motorists and crash locations

- CalTrans granted a $1,230,000 State Highway Operation and Protection Program (SHOPP) grant to fund Task Force-recommended construction projects.

- FHWA awarded a $10,000 Demonstration '92 grant to purchase public education material and conduct an evaluation of project

- CHP provided $ 5000 from their designated driver program for a designated driver poster in English and Spanish

Results: Preliminary statistics indicate a 75 percent decrease in number of fatal collisions, a 28 percent decrease in injury collisions and a 14 percent decrease in property damage only crashes. Although reportable crashes reduced across the county during the period analyzed, decreases in the corridor were significantly higher than elsewhere in the Monterey area.

5 CORRIDOR SAFETY IMPROVEMENT PROGRAM

A flow diagram of the Corridor Safety Improvement Program concept as identified for implementation in Arizona is contained in the following Figure 1. An overview narrative of the process is contained in this chapter. A more descriptive presentation of the program including the implementation of the CSIP institution is included in Chapter 8.

FIGURE 1 – CSIP PROCESS

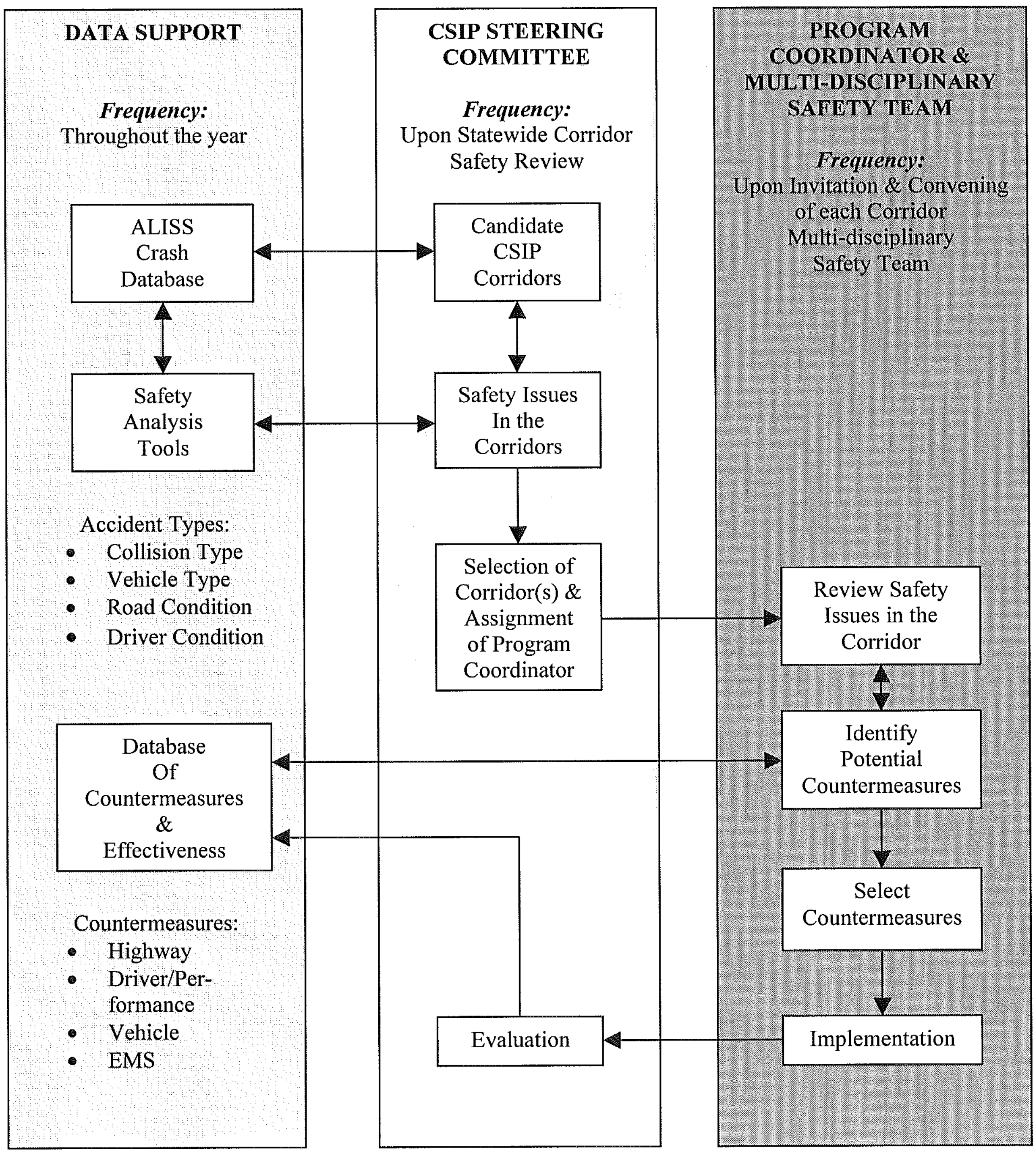


Figure 1 not only shows the flow of the CSIP process but also identifies the primary responsibilities of the involved groups with regard to the flow of the CSIP process. In reality, the delineations between the three groups will be less distinct. But since the proposed Arizona CSIP program is supported by factual information, a significant component of the process deals with data support. Therefore, the data support group is considered a very significant component in the success of a CSIP in Arizona.

Periodic statewide reviews of corridor safety issues will be conducted annually but may happen more often dependent upon a particular safety issue of concern that may rise out of special circumstances. The safety analysis tools, once they are developed to support the CLOSE program and the Priority Programming Process, will reveal safety issues that would be best approached with a CSIP. This is anticipated to happen as a by-product of the everyday work of the ADOT safety analysts.

The factual information in support of the CSIP process primarily consists of the ALISS crash database. Methods of determining high-risk corridors are provided by safety analysis tools and reporting techniques prototyped during this research. Additional information concerning roadway curvature, geometry, roadside appurtenances, and potential hazards can be supplied by feature inventory and centerline databases techniques that were demonstrated during this research. All of the factual information can be presented in a spatial format that identifies the risk factor of all user-defined corridors relative to each other. Also certain like subsections (i.e. two-way roadways through narrow landscape cuts) of corridors can be compared against like subsections in other corridors, or against the statewide average in order to assess the comparative risk.

From the factual information, candidate CSIP corridors are identified and the safety issues are documented. Up to this point, all work is done by the CSIP Program Coordinator with assistance from the ADOT Traffic Engineering Group, the custodians of the ALISS database and the CLOSE program. The results of the analysis are presented to the CSIP Steering Committee as a ranked listing of candidate corridors. High-risk subsections of non-candidate corridors identified during the screening process can be recommended for further study under the CLOSE program.

The CSIP Steering Committee then evaluates the candidate corridors and makes a recommendation for initiating the CSIP process on one (or more) of the higher risk corridors. Considerations include accident types, frequencies, and severity as well as the potential support for corridor safety improvement from local stakeholders along the corridor. Candidate corridors not selected for the CSIP process are then referred back to the CSIP Program Coordinator and Traffic Engineering Group for continued monitoring in subsequent screening processes.

Once a corridor is chosen, the CSIP Steering Committee and CSIP Program Coordinator convene a safety team from multiple disciplines who have an interest in affecting the safety along the chosen corridor. Further factual information is gathered, if necessary, to better define the issues of concern and better paint an understandable picture of the factual evidence.

The multi-disciplinary safety team (MDST) convenes for the first time at a location conducive to the stakeholders along the corridor. The MDST is presented with the wealth of data concerning the known issues along the corridor. The CSIP Program Coordinator then leads the MDST through a brainstorming session where a Safety Action Plan is developed. The Safety Action Plan is expected to include short-term countermeasures that may immediately affect the safety of the corridor as well as recommendations for the longer term when the corridor is programmed for more comprehensive rehabilitation and safety countermeasures can be implemented more economically. The plan should include assignment of responsibilities, funding, and scheduling so that at least two action items can be implemented within 12 months after convening the MDST for that corridor.

Implementation is, of course, largely dependent upon funding availability. Where the countermeasure involves education, enforcement, or EMS countermeasures, a grant application should be made to GOHS for Section 402 funding before the upcoming fiscal year begins. Where the countermeasure involves engineering or maintenance, appropriate applications for ADOT District discretionary funds, 5-year program funds, or CLOSE funds should be initiated. If an additional funding source develops out of the Transportation Equity Act for 21st Century (TEA-21) legislation, it could be earmarked for CSIP implementations so to not impact the existing funding sources.

Implementation should be monitored by the CSIP Program Coordinator and reported to the CSIP Steering Committee. Once each action item is deployed, measures of effectiveness should be established in the ALISS database and closely monitored on a monthly or quarterly basis in order to determine the effectiveness of each action item. Results should be shared with the MDST members and the CSIP Steering Committee, and adverse results should be quickly identified and corrected through appropriate actions. Measures of effectiveness, good or adverse, should be summarized and collected from other states for future CSIP studies.

6 TOOLS DEVELOPED TO SUPPORT THE CORRIDOR SAFETY IMPROVEMENT PROGRAM

In previous work, Lee Engineering built geocoding routines that relied upon a technique called dynamic segmentation to translate accident locations of a verbose description onto a linear referencing system (LRS) maintained by ADOT in a GIS environment. The study team installed the geocoding algorithms onto the ALISS database server in the Traffic Records Group and geocoded the entire ALISS file (as of December 5, 1997). The algorithms also make it possible for the newly entered crash records to become geocoded with the issue of a user command at any time.

An ArcView® shape file containing over 668,000 crash records during a 6+ year period was created. The supporting attributes of all crashes were downloaded from the ALISS server into a Microsoft Access® database container. The ALISS shapefile and the Access database container can co-exist on a single CD-ROM, enabling the study team to build supporting tools without being hooked live into the ADOT information technology architecture. Furthermore, the transfer to CD-ROM on a PC environment enables this technology to be portable to other transportation agencies in Arizona that may benefit in the future from ALISS spatial database technology.

6.1 MACRO TOOLS

The study team developed macroscopic tools for analyzing crash histories for the purpose of ranking segmented areas of highway in Arizona. The macro tools research consisted of exploring spatial (area or grid-based) analysis of crashes to locate clusters, as well as a network (intersecting roads) analysis of crashes along the State Highway System (SHS). The lessons learned from the development of the macro tools are explained below.

Spatial (grid-based) View

This method involves using GIS techniques to slice up the state of Arizona into tiles of a given user-definable dimension. The tiled grid is then overlain on the spatial crash database and the grids turn color to represent the number of accidents contained within each grid tile.

The benefit of the tool is spatial cluster analysis. This enables a database that has crashes coded to a specific section of US-60 or Grand Avenue (which are the same road in Maricopa County) to be counted in the same grid tile, without pre-processing the data to determine that US-60 and Grand Avenue are actually synonymous. Also the number of accidents in a grid tile is expected to be somewhat proportional to the centerline mileage within each grid. However, ArcView is able to normalize the total accidents with respect to the centerline mileage and offset the effect by presenting an accident rate as well as the frequency.

The negative aspects are that the spatial grid tiles do not represent any defined network connectivity that can help assess the relationship among accidents within the same grid tile or accidents in adjacent grid tiles. For instance, with grids that are dimensioned 1-mile-square, the contents of the grid could contain a mixture of accidents on principal arterials and local neighborhood streets in the same grid tile, leaving opportunity for confusion when assessing crash relationships along a corridor. Also, the size of the grids could cause small urban areas with high accident concentrations to be too fragmented and therefore not allow the grand clustering of accidents to be expressed.

Spatial (grid) analysis is a relatively low cost (i.e. low maintenance) manipulation of data with an equivalently limited benefit to corridor crash analysis. It depends upon a link to the Arc/Info® GIS engine or ArcView® Spatial Analyst to process the data. Subsequent research on network analysis has bypassed all benefits of spatial grid analysis. The study of spatial analysis propelled the research team to develop the types of tools that will be of huge benefit in the future.

Network (translated) View

The translated network view was developed after exposing the weaknesses of the spatial grid analysis. The research used the SHS of routes as the *scope*, or range, of interest. All accidents within a user-definable buffer distance (say 250 feet) around the SHS were selected and considered relevant to traffic safety and operations considerations of the SHS. The term *translated* is used to depict that accidents within the buffered area that were not attributed with the SHS route as the ON road, were translated to the nearest SHS intersection that they had connectivity with. This applies to both ® crashes within 250 ft on cross streets to the SHS, and © crashes referenced to an alias name of the SHS (i.e. Grand Avenue).

The graphical map output of the translated network view is useful when represented in ArcView **if** the user's eye can comprehend the entire state at once and pick out the largest clusters, which become very nondescript when zoomed out to view the entire state. Since this is not feasible, the real benefit of this macro tool is to provide a common denominator for each crash within 250 feet of the SHS. This common denominator is the SHS route reference in ATIS nomenclature. Therefore all accidents on Grand Avenue, US-60, and those accidents on 43rd Avenue and Camelback Road that are within 250 feet of US-60/Grand will all be referenced to "U 060" and each record is coded appropriately if it was translated from an *alias* route name or from a *crossing* route name.

Once all crashes along a corridor are referenced to the SHS route with appropriate *alias* and *crossing* attributes, the best macro tool for the discernment of high accident frequencies and rates is quite possibly the tabular query that the Traffic Studies staff and the CLOSE system has relied upon in the past. The major advantage of a *translated* database is that the data analyst doesn't have to worry about the Grand Avenue crashes when studying the US-60 corridor because they will be automatically considered when using the translated network. In the past, as evidenced in our previous work with the ALISS database and the Traffic Studies staff, analyses have been conducted which made improper assumptions and neglected crash records which should have been counted, if only they were all referenced to the SHS route that was being analyzed.

In summary, the translated network offers significant value-added features to the pre-existing ALISS database by translating crashes adjacent (or alias) to the SHS. It also shows that the spatial grid analysis is pale by comparison. Both of these tools are considered *macro* tools because they can easily assess the entire state and return a database that can then be queried to find the high crash frequency corridors which then require further detailed analysis by conventional database means.

In the following discussion, we will find that *micro* tools developed subsequently provide a lot more functionality and flexibility than the *macro* translated network view. These micro tools need not depend upon large tabular summaries and cross-tabs because they can be *scoped* to smaller data sets and therefore are better represented by graphic pie charts and bar charts in a GIS environment.

6.2 MICRO TOOLS

Several micro tools were prototyped by the study team. None of the micro tools are finished in the sense that they are useful to untrained personnel. Final development of the micro tools (beyond this research) will be necessary to make them independently beneficial to the Traffic Studies staff or future multi-disciplinary safety teams.

ALISS Attributes attached to Microfilm# (Individual Crash)

A relatively simple tool with the ability to display attributes for each crash was developed as soon as the study team turned its focus from macro statewide tools to micro tools which were designed to accomplish quicker queries on more isolated groups of data. These micro tools have a speed advantage over the macro tools, in that they allow for filtering of the data sets by date or area before conducting an analysis of the ALISS attributes of each crash.

One prominent negative aspect of this simple tool is the clustering of multiple crashes at the same location. A graphical representation of queried accidents at the same location show all these accidents as a single point. A queried accident may not stand out from a non-queried accident because the shapefile format placed the queried point beneath the non-queried point. The magnitude (or number) of accidents could not be clearly depicted without separating the chosen accidents from the unchosen. Therefore, an alternative method of grouping crashes into sections of roadway or areas around intersections (and then reporting the findings with pie or bar charts) was developed, as described below.

ALISS Attributes attached to Theme-based Crash Groupings

The cure-all for the obstacles that were evidenced by previous macro-tool spatial and translated network analysis, as well as individual crash identification on a micro-basis turned out to be the thematic grouping of crashes for purpose of displaying the results in a pie chart, bar graph, or line graph.

Thematic grouping refers to the ability of the user to define the extent of roadway to be analyzed by creating grouping themes. These themes may be anything the user chooses such as the following examples:

- All (or some) state highways broken into 1-mile segments between mileposts.
- All (or some) major point-to-point corridors between all (or some).
- All (or some) intersections.
- All (or some) traffic interchanges represented by polygonal areas that include ramps but exclude unconnected neighborhood streets.
- All (or some) two-lane roadways in urban areas carrying more than 2000 ADT.

- All (or some) segments defined in the HPMS database within all (or some) counties.

The point is that the user has utmost control over the scope of the query. The information returned for each query can then be:

- Represented as pie charts placed along the plan view of the scoped items for a query to extract the first harmful event for one or more groups (segment, point, or area) included in the scope.

- Represented as a bar charts placed along the plan view of the scoped items for a query to extract crashes where the first harmful event was "run off roadway" for one or more groups included in the scope to show the trend of such accidents over a six year period.

- Represented as a line (or multi-line) chart placed along the profile view of a corridor for a query to extract EPDO rates along the corridor to identify areas of potential concern.

Photo Log Linkups

This tool involves the display of photo images from the ADOT photolog inventory contained on CD-ROM. The images are accessible to the ArcView user by clicking the route location in an ArcView View window and retrieving an image of the roadway at the chosen location. Two methods were developed. The first method involved using ArcView's JPEG display capabilities to access each and any photo image in a one-by-one fashion. The second method involved using the ATIS Image Viewer software (developed previously for ADOT by Lee Engineering) to access the image, as well as all of the neighboring images via VCR-type controls, to get a motion picture of travel along the roadway.

The tool's principal benefit is to give the user an image of any road by pointing to a map. As discussed in the next sections on photolog inventories and crash statistics also available in ArcView, this tool is very useful in providing a visual image for assessing signing and striping inventories in areas of accidents, or for assessing crashes in a particular configuration of signing and striping.

Photo Log Inventories

The study team trained with personnel in the Traffic Studies Group to adapt the ATIS Image Viewer software (developed previously for ADOT by Lee Engineering) to specific tasks deemed helpful to corridor safety analysis. The ATIS Image Viewer was used to collect the following information from the US-93 photolog:

- No Passing Zones
- Passing Lanes
- Guardrails
- Roadside Landscape Cuts
- Shoulder Wayside Locations
- Developed Intersections
- Undeveloped Intersections
- Sign Inventory
- Headwalls
- Other Fixed Objects

The study team compiled an inventory database of approximately 2400 feature instances along the 100 miles of US-93 that were studied. Many features are composed of two instances (i.e., a beginning point and an ending point). Other features (like signs and intersections) can be identified as one instance (i.e., a point). The ATIS Image Viewer was useful and efficient in collecting the feature inventories at a swift pace of up to 100 feature instances per hour. The databases were then used in a GIS environment with the global positioning satellite (GPS) - collected curve and grade profiles as described below.

GPS Curve and Grade

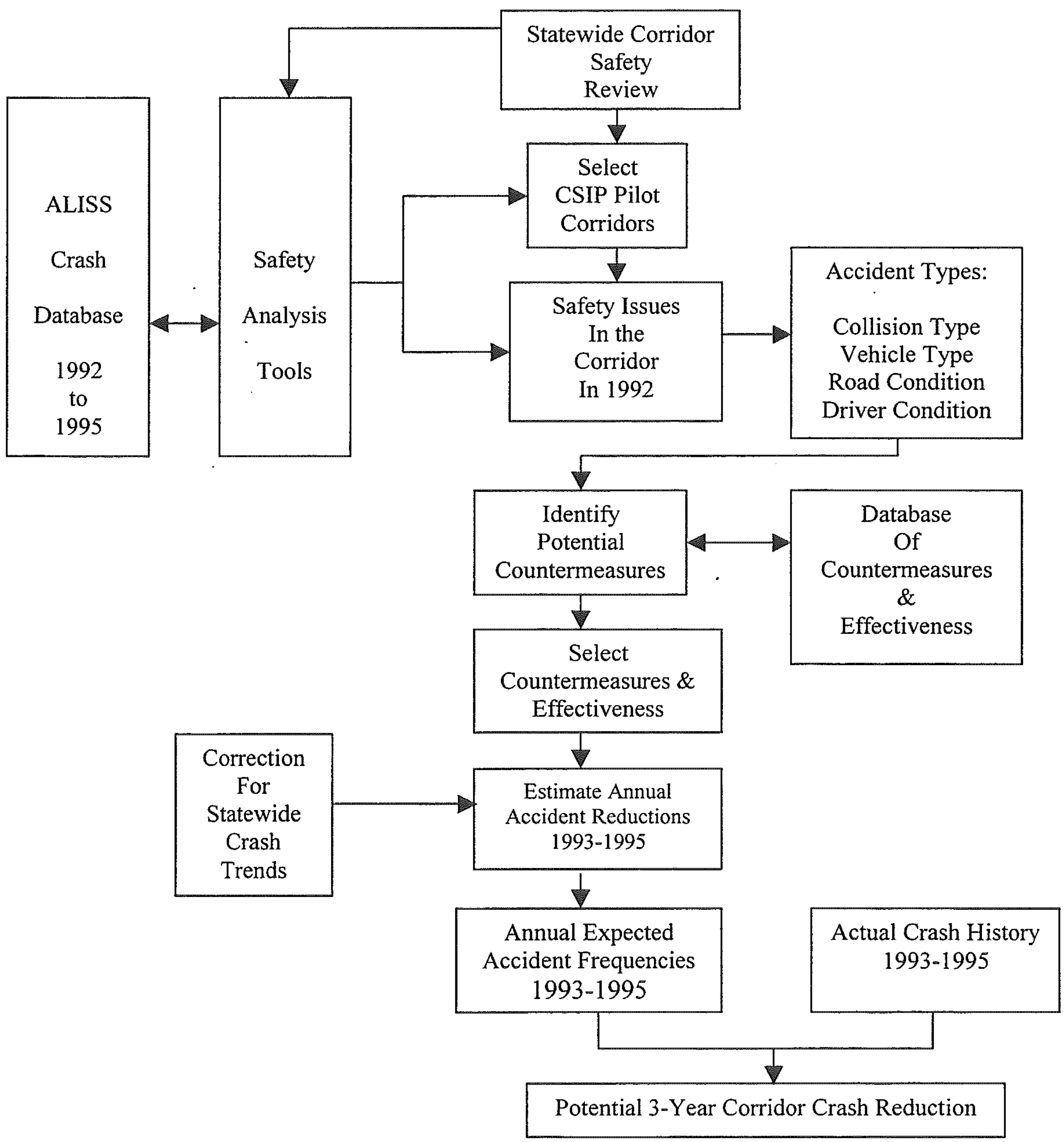
This tool showcased ADOT's state-of-the-art high resolution GPS centerline collection software. ADOT staff traveled the selected corridor and produced some centerline files that depict the actual plan and profile of the corridor at sub-meter accuracy with a point collected for every half-second of travel. This data has an enormous potential in allowing ® accidents to be plotted in reference to grades (i.e. the *x-z* dimension rather than just the *x-y* dimension), and © passing sight distances, curve radii, and grade inclines to be approximated from GIS views. Furthermore, the potential for analyzing roadside furniture and signage locations in the *x-z* dimension promises to give the traffic safety engineer and the multi-disciplinary safety team members a very unique perspective on crash history. The tool also provided the ability to pick a feature in plan view and have the same feature automatically become viewed in the profile view. This also works vice versa.

7 PILOT STUDY

A pilot study was conducted to present the CSIP process data analysis and display tools in order to promote a new awareness among the Arizona safety community that the ALISS database can deliver better information in this age of improved technology. This better information can be the catalyst that enables safety-concerned workers at all agency and private levels to openly adopt the new methods. These methods may include the implementation of a formal CSIP process in Arizona, and the organization of multi-disciplinary safety teams.

The approach suggested for the Pilot Study of a CSIP is shown in the following Figure 2.

FIGURE 2 - PILOT STUDY



7.1 MEETINGS OF 4E DISCIPLINES

In June 1998, meetings of the 4E disciplines were convened in Phoenix for the purpose of gathering support for a CSIP from agencies outside of ADOT. The list of invited participants is included in Appendix A. Representatives of the FHWA Phoenix office and from the Governor's Office of Highway Safety were invited to all four meetings.

The format of each 4-hour meeting included introductions, an overview of study goals and objectives, and overview of the meeting goals and objectives. Then the GIS and analysis tools were presented and followed by an open forum review of the pilot corridor safety record. Following a brown-bag working lunch, there was a brainstorming session and a ranking of key issues from the perspective of the convened discipline. Then typical countermeasures that were available for implementation from CSIPs in other states were presented along with measures of effectiveness, if available. From there, the group formed a desirable action plan for the convened discipline. The meeting ended generally by 2:30pm with closing remarks and an evaluation of the CSIP process. Of particular interest to each of the 4E meeting groups was the determination of a project champion who would carry forth a CSIP implementation scheme for Arizona.

The appendix contains the handout material presented during the 4E meetings. This includes proposed agendas, common material from all meetings, and material specific to each meeting. The meeting notes from each of the meetings are also included as separate exhibits.

7.2 MDST WORKSHOP

The multi-disciplinary safety team workshop consisted of a 4-hour session with the same invitees of the 4E meetings. The end purpose of the workshop was to establish a consensus among the multiple disciplines about the value of a CSIP in Arizona and to present a draft implementation plan. Along the way, the study team also introduced the theory of multiple objective decision making and led a discussion of the most appropriate action items that could be implemented to provide remedies to the safety concerns along the chosen corridor. Finally, each participant produced a list of their top three remedies for the corridor. The lists were later summarized and distributed with the minutes of the workshop. The minutes from the workshop are included in Appendix G.

7.3 CONCLUSIONS FROM THE PILOT STUDY

The groups that assembled for the 4E meetings as well as the MDST workshop felt that the analysis tools demonstrated during the pilot study offered significant advances to the process of safety improvement identification. Most agreed that the tools would be useful to agencies other than ADOT if they are developed to user-friendly specifications.

The CSIP process itself was given high marks as an effective implementation scheme for forwarding the cause of corridor or community safety. The concept, which simply boils down to cooperation between different entities with the same cause (but different perspectives) in mind, was regarded as common sense. The analysis tools were seen as a catalyst to the cooperation process because factual evidence can be easily extracted from the ALISS, and other, databases to allow professionals from different backgrounds to agree on the nature of the problem before implementing an action plan to solve (or minimize) the problem.

The entire group concurred that the biggest hurdle in the CSIP process will be the identification of a champion for the program. The GOHS was viewed as one of the potential agencies to be the champion for the CSIP. This agency works closely with the Education, Enforcement, and EMS disciplines at a community level. Guided by CSIP principles, the decision and funding mechanisms that GOHS currently uses would be positively reinforced by analysis tools for identification, and the consensus building for the implementation, of the most effective action plans.

Since many engineering remedies for safety improvement generally involve costlier action items, it is unlikely that GOHS would be expected to fund engineering improvements from NHTSA funding that currently serves the other three Es. The major benefits realized during the pilot study are the cooperative features that the multi-disciplinary safety teams offer to determine the most effective action plan. Once the remedies are identified, ADOT can program engineering improvements with CLOSE funding or discretionary funding at the district level, if not a full-blown project scoped into the 5-year program through the Priority Programming Process. GOHS can appropriate Section 402 funds to methodically address the non-engineering concerns of the corridor/community. The point is that Arizona could have an integrated process of dealing with safety improvement identification and implementation if a champion comes forth.

8 CSIP IMPLEMENTATION PLAN FOR ARIZONA

The necessary steps for implementation of a CSIP in Arizona are outlined in this implementation plan. Although the general methodology and guidelines for conducting a CSIP are well established, the initiation and launching of such a program seems to require a substantial level of cooperation and coordination among the key agencies concerned with highway safety. It is doubtful if a successful CSIP effort can be launched without such cooperation. It is also evident from what other states have accomplished that such a program will certainly benefit the entire state by improving the overall level of highway safety.

Implementing a CSIP in Arizona will require program leadership by a proactive agency that will promote the benefits of such a program and obtain buy-in and support from the other key stakeholders. The key agencies concerned with highway safety in Arizona are performing functions that could easily fit within a CSIP. Based on the success of similar programs elsewhere and the level of enthusiasm for a CSIP shown by the individual agencies that participated in this study, it is clear that a CSIP is a win-win proposition for all participating agencies. Establishment of the institutional framework to support launching of a CSIP in Arizona seems to be the most important action necessary at this time.

The following is a description of the essential steps for launching and implementing a CSIP in Arizona.

Phase 1: Establishment of an Institutional Framework

1. Steering Committee

The first step required for a CSIP in Arizona would be the establishment of an institutional framework and a supporting management structure. Success of the program would depend largely on the level of support and cooperation generated by the CSIP program among the key agencies that are responsible for ensuring highway safety in Arizona. A steering committee that consists of top level management from the key agencies in the state concerned with public safety is recommended. This committee would provide oversight and the institutional support for this effort. Since the goals and objectives of a CSIP are closely aligned with that of the Arizona Safety Management System, it may be feasible to mobilize the SMS Committee to recommend the establishment of a CSIP steering committee.

As the custodian of ALISS crash database, it would be essential that Arizona DOT play a pro-active support role in a CSIP. Candidate agencies for the steering committee are:

- Arizona Department of Transportation (ADOT)
- Arizona Department of Public Safety (DPS)
- Governor's Office of Highway Safety (GOHS)
- Arizona Department of Health Services (DHS)
- Federal Highway Administration (FHWA)
- National Highway and Traffic Safety Administration (NHTSA)
- American Automobile Association (AAA) of Arizona
- Council of Government (COG)

One of the key issues/problems in creating any new program is the identification of funding sources that would support such a program. However, a review of on-going highway safety improvement programs in the state indicate that existing funding sources and programs may be adequate for launching a CSIP and may result in higher effectiveness achievable through better coordination.

On-going programs such as the CLOSE Hazard Elimination Program by ADOT and Section 402 funded programs conducted by GOHS already perform a number of the key functions of a CSIP. However, a CSIP would be able to improve the overall effectiveness of these individual efforts through the multi-disciplinary approach towards corridor safety improvements. The Safe Communities Program by NHTSA is another possible source of funding that feeds to the multi-disciplinary approach to safety. Such an approach is likely to be supported by the steering committee that is well represented by the four key disciplines. It may be helpful to produce and distribute a white paper on the successes of CSIP programs such as that led by the California Highway Patrol in California.

One possible course of action is for the SMS committee to make a recommendation and a request to the Governor to establish a CSIP steering committee. Once the CSIP steering committee has been established it would appoint a lead CSIP agency.

2. CSIP Lead Agency

The first action for the CSIP steering committee would be to appoint a lead state agency for implementing and coordinating this program. The lead agency should establish a CSIP Program Coordinator with the responsibility to develop, coordinate and manage the program. A review of on-going efforts that are related to a CSIP in Arizona indicate that the GOHS would be a good candidate agency for the lead role. Due to a lot of commonality between CSIP initiatives and on-going safety programs that are being carried out by GOHS, it is clear that these two efforts will compliment each other very well.

The most successful CSIP of recent times seems to be the effort in California, lead by the California Highway Patrol. One CHP staff person has been assigned to the statewide CSIP program. The levels of support that the program has generated among all the agencies, and the results on program effectiveness to-date, have clearly justified the program.

Depending on available staff resources at the lead agency, perhaps an existing staff member could be assigned the role of the CSIP Program Coordinator for the state. The feasibility of establishing a new position for this function should also be explored. The level of emphasis on safety in the TEA 21 indicates that it would not be difficult to justify or find required resources to support such a staff position.

The CSIP Program Coordinator will work with the key agencies to develop, promote and seek funding for the CSIP program.

3. Identify Key Agencies

Information gathered during the US-93 pilot study enabled the identification of a number of agencies that will be essential participants for launching a successful CSIP in the state. They are:

- AAA Arizona
- National Safety Council
- Councils of Government or Metropolitan Planning Organization
- City, Town and County Engineers
- Citizens Groups – MADD, SADD
- Chambers of Commerce
- Other agencies or jurisdictions – Forest Service, National Park Service

A database of all the key agencies and primary contacts in the state should be prepared as a resource for corridor projects. Appropriate agencies would be contacted to participate in specific corridor teams that will be responsible for developing Safety Action Plans.

Phase 2: Establish Procedures for Selecting Corridors

The steering committee should establish systematic procedures for identifying candidate corridors as well as select the candidate corridors to be studied using the CSIP process. Statewide review would be conducted using the ALISS database, the GIS safety analysis tools prototyped as part of this study, and an established set of criteria for screening candidate corridors. The screening should be based on crash data from the previous 5 years and other input from Department of Public Safety, ADOT District Engineer, Maintenance Engineer, councils of government or metropolitan planning organizations, and feedback by road users.

1. Corridor Definition

The 1994 State Transportation Plan identified 14 strategic transportation corridors for Arizona. Transportation Planning Group (TPG) now has 32 "corridors of significance" listed, with 14 multi-modal studies completed and 18 slated for future completion. These corridors may serve as a good starting point for identifying candidate corridors. If previous findings from multi-modal corridor profile studies have indicated corridor safety problems, they should be included in the list of candidate corridors. An annual survey of the key agencies should be conducted to identify additional candidate corridors.

The process of selecting candidate corridors should be sufficiently flexible to accommodate urgent projects that may be necessitated by prevailing unique conditions, short of waiting for 5 years of corroborative data from ALISS. Such short-term projects may result in substantial benefits through crash prevention. Other corridors may benefit from a concurrent CSIP process to support studies of another nature in order to render recommendations that can be implemented as part of an upcoming capital improvement project.

Rural Arizona has a predominant characteristic of long stretches of roadway with few (if any) communities alongside. This characteristic differs from successful CSIP study corridors revealed during this research. Successful CSIP teams in other states typically included a number of active communities that provided a local influence to champion the safety improvement process. This must be taken into consideration when developing a CSIP process in Arizona. If the candidate corridor is significantly fragmented by such distances that the communities do not mutually affect or depend upon each other, it may be best to segment the corridor into more manageable lengths with mutual concerns. Therefore, target corridor lengths of 10 to 40 miles that were designated in other states should only be a *reference* for establishing corridor limits in Arizona.

When defining the physical limits of the candidate corridor, logical roadway configuration should be taken into account. For example, natural termini such as freeway interchanges or intersections with major routes would serve as good candidate corridor limits. Candidate corridors that run through a community should not terminate within the community limits, for the purpose of achieving maximum community support for the CSIP process.

The list of candidate corridors should then be screened for their suitability as a CSIP project.

2. Screening of Candidate Corridors

Once the list of candidate corridors has been identified, it should be subjected to a screening process. The following criteria or questions would supplement the crash record and other forms (i.e., prevailing conditions or special studies) of input:

- If the candidate corridor is slated for decommission from the State Highway System, there is no reason for the State of Arizona to champion a CSIP unless the receiving local agency specifically stipulates the need for a CSIP and is willing to champion the process itself.

- If major rehabilitation (entire corridor or part of) is programmed in the near future and safety issues have not yet been addressed by a MDST, then it still should be a candidate corridor so that education, EMS, and enforcement concerns can be addressed.

- If recently completed improvements for the candidate corridor have supposedly addressed safety problems, then the corridor should be monitored rather than studied.

- Would any recent or planned changes along the corridor heighten future safety concerns?

- Would potential local agency funding of the CSIP process and/or subsequent potential improvements further advance the State-sponsored cause for safety along the corridor?

- Are there sufficient potential local champions with human resources and key agency personnel for supporting this project?

Negative answers for any of the above criteria or questions should not disqualify any candidate corridor, but rather establish the tangible considerations that should be superimposed upon the outcome of the crash ranking.

3. Criteria for Ranking Candidate Corridors

At least three years of crash data should be used for this ranking process. The following corridor safety criteria are recommended for ranking of problem corridors:

Corridor traffic volume - in the case of long corridors, weighted average may be used
Fatality Rate (FR) - number of fatal collisions per 100 million vehicle miles of travel

Mileage Death Rate (MDR) – number of people killed per 100 million vehicle miles of travel (VMT)

Combined Fatal and Injury Rate (FR+IR) - fatal and injury collisions per 100 million vehicle miles of travel

Crash Frequencies Weighted by Severity – fatal x 5 + injury x 3 + property damage only x 1, or equivalent property damage only (EPDO)

These are some of the factors that could be considered, but there could be others. The candidate corridors can be sorted and ranked based on **FR**, **MDR**, **FR+IR**, or **EPDO** as risk measures. The above rankings can then be combined into a single ranking of candidate corridors.

4. Selection of Corridors

The selection of corridors from the listing of ranked candidate corridors should be conducted by the Steering Committee. The number of corridors selected should be established based upon the funding available for administering the individual processes, with consideration for set-aside funding of potential countermeasures that will also be funded in any budget year.

Phase 3: Launch Corridor Safety Projects

1. Convene a Multi-Disciplinary Safety Team (MDST) for the Corridor

Responsibility: Program Coordinator

When a corridor has been selected, the CSIP Program Coordinator convenes a meeting of the stakeholder agencies from the affected region to form a Multi-Disciplinary Safety Team (MDST). The MDST will be briefed on the concept of CSIP and shown examples of other CSIP project results, CSIP guidelines and other documentation. The MDST chair and vice-chair will be appointed at this meeting. Beyond this meeting, the role of the CSIP Program Coordinator will be limited to the functions of facilitator and coordinator of MDST activities. The CSIP Program Coordinator will attend all MDST meetings and will be available to provide supporting documents and other information.

2. Prepare Specific ALISS and Photo Log Information for use by the MDST

Responsibility: Mostly ADOT – minimally DPS and DHS.

In order to aid and support the decisions of the MDST, factual information regarding the study corridor should be gathered and assimilated in a format compliant with the positive and useful findings of the tool-building process associated with this research. This information should include roadway imagery, 3-D centerline geometry, striping, signing, roadside furniture inventories, recent and programmed projects, and historic crash characteristics.

The information should be portable so that it can be readily reviewed by MDST participants prior to formal meetings, as well as be carried to MDST meetings at remote sites away from the ADOT campus and ADOT electronic networks. The distribution medium should be digital CD-ROM multimedia so that information can be easily conveyed and understood by non-technical participants.

Reporting techniques should be specified upon further development of the safety analysis tools. The reporting methods employed for this information should be an offshoot of the formats and techniques that would otherwise be developed for future sole use by ADOT only. However, specific formats of conveying crash attributes significant to EMS, enforcement, and education issues must be adhered to for the purpose of identifying potential non-engineering countermeasures, which typically are less costly than engineering fixes.

3. Review of Corridor Safety Issues

Responsibility: MDST

MDST meets at least quarterly during the project duration for work sessions to review corridor conditions. The goal of these sessions will be to identify at least four factors that contribute to traffic safety problems in the corridor. For each of the factors, the MDST should identify corresponding potential short- and long-term solutions. The problem factors should include road conditions and driver behavior.

4. Develop Corridor Safety Action Plan

Responsibility: MDST & Program Coordinator

Develop and publish a Safety Action Plan that identifies the following as a minimum:

- Corridor safety issues
- Short- and long-term countermeasures
- Issues that need to be studied
- Assignment of responsibility
- Identification of funding sources
- Implementation schedule
- Correlation with programmed projects

5. Implement two of the solutions within 12 months after the MDST is convened

Responsibility: MDST & Program Coordinator

Subject to funding availability, the MDST will strive to implement at least two solutions identified in its plan within 12 months after it convenes.

Phase 4: Project and Program Evaluation

Responsibility: Steering Committee

The CSIP Program Coordinator will prepare the final report on each project for review and acceptance by the Steering Committee. This report will include the following:

- Safety Action Plan
- Project Evaluation by the MDST
- Before and After Accident Statistics
- A Discussion of the Attainment of Project Objectives.

The CSIP Program Coordinator will also compile an annual report on the CSIP process for review and acceptance by the Steering Committee. This report will include:

- Accomplishments during the program year
- Recommendations for amendments to the CSIP process

9 INSTITUTIONAL ISSUES

9.1 PERSONNEL/RESOURCE ISSUES

Various activities conducted during the execution of this study required the participation by key stakeholder agencies. Although significant efforts were made to draw personnel from these agencies to participate in the study, these efforts met with limited success. Many agencies are short handed and are unable to spare staff to participate in efforts that are beyond their current responsibilities. Although the responsible decision-makers expressed willingness to participate in the study, many were unable to find the staff resources for doing so.

A properly designed process for a statewide CSIP should accommodate this issue. Holding meetings within the corridor encourages community involvement. Offering the supporting factual evidence (ALISS, ATIS, photo log, GPS, and inventories) can generate participation and enthusiasm in the local community and not just those participants in the CSIP. This way the investment in the CSIP process can spawn other safety-related programs within the community and a return on investment may be realized through improved safety throughout the community.

9.2 FUNDING ISSUES

Funding is, and will always be, a critical issue in transportation. The safety programs supported by Section 402 funds are administered solely by GOHS. The beneficiaries of this funding are mostly the education, enforcement, and EMS stakeholders who apply for grant consideration through GOHS. ADOT administers it's own funding for the CLOSE program, highway projects, and roadside maintenance.

Under a CSIP process, the two agencies can continue to sponsor projects each in their own areas using their own funds (ADOT for engineering and maintenance – GOHS for education, enforcement and EMS programs). The most important issue is that collaboration, irrespective of funding, should allow the problem and the most appropriate countermeasures to be better identified. Until inter-agency collaboration allows the problems to be identified and solved from multiple perspectives, nobody will be able to quantify the most advantageous benefits for the applied costs.

9.3 PRIORITY PROGRAMMING ISSUES

The existing project programming procedures within ADOT as well as GOHS must accommodate the recommendations and action plans that a MDST delivers through the CSIP process. A review of ADOT's project programming system indicates that input regarding safety issues from an overall safety management system has long been awaited.

The GOHS staff should recognize the action plans developed from MDST meetings as qualified recommendations from informed committees designed to address specific safety issues on corridors that have been identified as the most hazardous in the state. This collaborative prequalification should be ample reason for considering and securing Section 402 funding to address the identified problem, perhaps ahead of other grant requests that come from individual disciplines or special interests.

9.4 JURISDICTION ISSUES

The application of this research has focused upon the safe operation of the State Highway System by ADOT and other agencies. However, many of the procedures presented should be applicable to non-state highways and streets or communities in general. Therefore, the concept of CSIP should be defined such that relatively short corridors or small communities can benefit from the process as well as the analysis tools.

The ALISS database is intended to represent every motor vehicle crash in Arizona involving a fatality, injury or property damage in excess of $500. ALISS contains a comprehensive accounting of crashes on non-state roadways if crash reports are furnished to ADOT. However, several tribal nation law enforcement agencies have withheld crash reports from the State of Arizona for a number of years claiming sovereignty issues. This somewhat affects the calculation of statewide averages and keeps some problems in those affected regions from being identified. However, the safety analysis tools and the CSIP process could play a role in bridging the gap between the State of Arizona and all local government agencies if the tools and process are properly implemented and demonstrate positive results. The end effect is that some of these agencies may be willing to produce their crash reports if ADOT can offer effective tools and a comprehensive program for dealing with traffic safety.

9.5 RISK MANAGEMENT ISSUES

A great concern to all parties involved with highway safety programs is the minimization of potential risk by keeping a tight wrap on all information which could be used against an agency to satisfy a claim arising out of a motor vehicle crash. The discussions of this research suggest that information should be open and accessible to multitudes of agencies that can benefit from its application to improving highway traffic safety. However, open and accessible information is likely to fall into the wrong hands and eventually be used against the custodians of that data.

Therefore, it is important for ADOT and the State of Arizona to develop updated policies for the distribution and use of ALISS data. Currently, ALISS data is available through the Traffic Records Section under the Traffic Engineering Group at ADOT, but the printed code format of the information often dissuades the user from doing extensive data mining operations to prove or disprove an argument. Once the data becomes available in GIS format, the capabilities of the data grow exponentially, as does the probability of the data being misused or misinterpreted.

It is important for policy makers to first develop, implement, and fine tune a safety management system (such as CLOSE or CSIP) before extending that system (or the data thereof) to other parties. The safety management system must be defensible—as to minimize the exposure that the agency assumes for safety projects identified and prioritized, but not funded due to a lack of available funding.

10 CONCLUSIONS

The implementation of a Corridor Safety Improvement Program for Arizona and its communities will facilitate a forum for the multiple stakeholders and the different disciplines to recognize and identify the most appropriate safety-related countermeasures for implementation on a corridor-by-corridor basis across Arizona.

In the process of arriving at the above statement, several findings were identified in support of implementation of a CSIP in Arizona:

- Several safety analysis tools demonstrated during the pilot study were found to be effective and useful in understanding the safety characteristics of Arizona roads. Pre-existing tools employed until now have not been capable of rendering such comprehensive spatial and visual analyses in formats understood by lay persons. Further development of these tools will be necessary before the CSIP process can benefit, however.

- The multi-disciplinary approach provided an open forum for discussion and revealed to many participants that many safety-related problems are best solved by a combination of engineering, education, enforcement, and emergency medical service countermeasures.

- Funding to support a CSIP process could be secured from upcoming increases in federal funding through the Transportation Equity Act for the 21st Century (TEA-21). Funding for identified countermeasures can come from a combination of CLOSE funds, district discretionary funds, 5-year program funding, Section 402 funding, or future additional funding through TEA-21. At a minimum, recommendations for safety improvements can be specified for future longer-term programming where funding is not available for the near-term.

- ADOT's Traffic Engineering Group has expressed a willingness to champion the CSIP process. The usefulness of the safety analysis tools and the analytic procedures that lay a foundation for the CSIP are beneficial to Traffic Engineering Group in its everyday work (i.e. spot safety improvements and traffic safety in general) in addition to being beneficial to the multi-disciplinary approach to corridor safety management.

These findings lead to the recommendation for implementation of a CSIP as described in Chapter 8. Prior to the deployment of CSIP processes, additional recommendations to support the Priority Programming Process as well as the CSIP should be carried out as detailed in the next chapter.

11 RECOMMENDATIONS

This study is specific in recommending a Corridor Safety Improvement Program for Arizona and its communities (see Implementation Plan in Chapter 8). However, the success of such a program in any state is dependent upon the delivery and use of factual evidence to support the decision-makers. Factual evidence minimizes the cloak of uncertainty underlying the specific hunches or gut feelings of the observers. In this age of increased data availability, a certain effort must be made to avail one's self with the proper facts before rendering a decision. On the other hand, too much data or improperly presented data may cloud the issue and make it more difficult to develop a true perception of the conditions.

Two things are important to consider for anyone using the ALISS database. First, there is ample opportunity for significantly improving the ALISS electronic crash reporting and input mechanism in order to minimize known problems with locational attributes of crashes and the way they display, either spatially or tabular. Second, the level of analysis that ALISS and its current reporting facilities offer to analysts will not support a CSIP process adequately. There is too much chance for confusion and the current relative inaccessibility of the ALISS database within ADOT must be improved if other disciplines (or even other engineers) are expected to make sense of what the database holds.

As recommendations of this study are funded and deployed, specifications for tool development should be drafted by ADOT Traffic Studies personnel (and others with an interest in the safety analysis requirements of the tools). The specific areas of consideration for further tool development follow.

11.1 INPUT TO THE PRIORITY PROGRAMMING PROCESS

Research during the early tasks of this study detailed the Priority Programming Process of the Transportation Planning Group and its need for establishing safety considerations into its project-screening matrix. Previous screening functions (prior to the revamped PPP in mid-1977) used a 22-point system that used geometric and operational guidelines to rank a project for inclusion in the pool of programmable projects. Currently, the revamped PPP still allows for a safety ranking for each project in the pool of programmable projects. However, safety scores have not been tabulated for programmable projects because of a lack of methodology for tabulating these scores.

The demonstrated methods for *identifying* safety concerns can serve at least **three** programs—CSIP, CLOSE, and the PPP. For the CSIP and CLOSE, the tools identify possible locations and corridors of high safety risk for further study under CLOSE or CSIP. For the PPP, the same tools are used to evaluate a "safety score" for given stretches of highway designated as programmable projects (often due to pavement preservation needs).

The Traffic Studies Section should work with Priority Programming to develop a methodology for ranking each programmable project in the pool according to it's traffic safety record as contained in ALISS. The score can be as simple as providing an equivalent property damage only (EPDO) rate per million vehicle miles of travel (VMT). It may be more complex and involve only certain types of accidents that the programmable project is expected to affect. Either way, the system can use safety information to attain a multi-objective ranking so that, all other things being equal, a hazardous stretch of highway gets attention prior to a relatively safer section of highway.

11.2 ALISS DATABASE POPULATION & ATIS ROADS UPDATE

Only 80% of the ALISS crash records (96% of those on the state highway system) can be effectively translated to spatial coordinates and represented by GIS [2]. In other words, one out of five records are input to ALISS without sufficient "location" attributes for the type of spatial analysis that the analysis tools provide. This represents a waste of 20% of the effort that is spent on the data input process. Furthermore, it also represents that 20% of known accidents are not available for analysis by spatial analysis tools.

ADOT has recognized the above fact since late-1996, if not earlier. Currently, the Traffic Records Section is securing funds to begin updating the data input methods for ALISS to a contemporary computing environment. Still, much of the problem with achieving sufficient location attributes lies with the ATIS Roads coverage, which is out of date. In a concurrent effort, the Data Team of the Transportation Planning Group is promoting a project to upgrade the ATIS Roads database so that it is current with Arizona's existing highway infrastructure at the local government level, as well as the state-owned roads.

Both of these projects will accomplish extensive upgrades in database reliability and efficiency. However, neither of the projects (at their present funding levels) is expected to deliver all of the desired outcomes from an agency-wide perspective. Since the ALISS upgrade supports the proposed CSIP process, and since ATIS Roads is designed to accommodate all ADOT and Arizona transportation data users, this study recommends continued support and funding in subsequent phases of both of these projects.

11.3 ANALYSIS TOOLS AND ALISS DATABASE ACCESSIBILITY

During this research, the ALISS database was joined to a GIS database of the crash locations, allowing the ALISS tables to be presented in a contemporary GIS environment for the first time ever. This joining in a CD-ROM (or large hard drive) environment lends a great deal of flexibility in presentation of the databases. The comments of the participants of the pilot study support the need for making ALISS data more accessible to agencies other than ADOT, as well as more people within ADOT.

Currently, the prototype environment developed during this study is in use at ADOT Traffic Studies Section by one trained staff member. In the future, emergency medical service, public education, and law enforcement personnel can use the ALISS database independent of the engineer's point-of-view.

Therefore, the ad hoc reporting capabilities of the ArcView extension must be further developed or enhanced to support more potential users and the CSIP process in general. Procedure manuals and reference documentation should be written to support these tools. Training classes should be organized to promote the use and usefulness of the tools. Continued development of the prototype tools and environment is recommended. This development is required for a successful CSIP implementation.

11.4 PHOTO LOG AND FEATURE INVENTORY

The capabilities of the ADOT photo log that were developed during this research revealed an extensive applicability to corridor safety analysis as well as feature inventory in general. Nearly all development of this technology took place under previous contracts between Lee Engineering and ADOT. The ATIS Image Viewer allowed untrained personnel to become quickly trained to attain a feature capture rate of up to 100 feature instances per hour. This is a phenomenal rate of data acquisition that can be increased through further development of the ATIS Image Viewer. For instance, the tool would be faster if it tracked linear features with a linear data model rather than a point data model. Also, the translatability from tabular database to GIS should be streamlined to make the tool function in a more user-friendly fashion.

The tool has a double benefit in ® assessing current roadway and roadside conditions and © using those conditions as a basis of query to substantiate the remedy. For example, if installation of guardrail is a potential viable countermeasure, the extent and location of existing guardrail is important in determining the amount (hence cost) of additional guardrail to be installed. But just as important, the segments of roadway with existing guardrail can be compared to the segments without guardrail to determine if the existence of guardrail has a beneficial effect on the severity or number of accidents where the vehicle leaves the roadway.

Therefore, continued development of the ATIS Image Viewer photo log feature inventory tool is recommended. This should include the creation of a user documentation and establishment of a training program for potential users.

Furthermore, in order to conduct reliable evaluations of safety risk in support the CSIP process, feature inventory databases (such as an accurate guardrail inventory or an accurate regulatory sign inventory) will have to be developed. These databases should be capable of supporting inventory management systems (which manage the feature itself) as well as safety management systems like CSIP (which manage the effectiveness of the message delivered by the feature). Current efforts in other workgroups in ADOT are investigating the most cost-beneficial methods for acquiring feature inventories.

It is recommended that ADOT support feature inventory in general. It is further recommended that ADOT specifically support feature inventory systems that are cost beneficial and satisfy the multiple objectives of different workgroups. This will prevent the added expense of maintaining duplicate feature inventory databases and lead to enhanced reliability in single databases.

11.5 GPS CURVE AND GRADE

The tools available to the research team via existing global positioning system (GPS) technology currently within ADOT proved to be helpful in assessing the horizontal curvature and vertical gradients of the roadway centerline. The research exploited the tools to the extent that they were developed under previous contracts between Lee Engineering and ADOT. Future considerations for development of the tools could support:

- A virtual sight distance calculator that combines the plan and profile views of the centerline to determine the vertical sight distance automatically at every 1/100th of a mile along the State Highway System. This feature could then incorporate the photo log to assess the horizontal clear distance along a stretch of highway to determine the virtual sight distance. These virtual distances can be compared to the no passing zones to determine where no passing zones might be adjusted or passing lanes might be installed.

- A query mechanism that allows the analyst to assess accident rates relative to radius of curvature or gradient of centerline. This option would establish the first of its kind background data on the correlation between crashes (perhaps of a certain type) and the curvature/gradient of the highway.

APPENDIX A

PARTICIPATION LIST AND GENERAL CSIP MATERIALS

CSIP Invitee List

	Law Enforcement 6/9/98	Education 6/11/98	EMS 6/18/98	Engineering 6/23/98	MDST 7/1/98
Capt. John O'Hagan, Yavapai County	X				X
Lt. John Tibbets, DPS Kingman	X/A				X
Greg Smith, Mohave County	X				X/A
Steve Enteman, DPS Education		X			X
Dennis Duffy, ASU/DPS	X/A	X/A			X
Alberto Gutier, GOC&HS	X	X			X
Phil Bleyl, FHWA	X/A	X/A	X	X/A	X/A
Cydney DeModica, AAA Az		X/A			X/A
Matt Burdick, ADOT		X			X
Chad Ettmueller, NSC AZ Chapter		X			X
Bob Hall, ADOT		X/A			X/A
Steve Powles, DPS EMSCOM			X		X/A
Steve Davis, DPS Air Rescue			X		X
Tom Evans, Wickenburg PD			X		X
Susan Kern, River Medical, Kingman			X		X
Mike Caswell, River Medical, Kingman			X		X
Chuck Manuel, AZTech MDI/Phx Fire			X/A		X/A
Steve Owen, ADOT			X	X/A	X/A
Dave Duffy, ADOT				X/A	X/A
Reed Henry, ADOT				X/A	X/A
Bob LaJeunesse, ADOT				X	X
Jim Glasgow, ADOT				X	X
Terry Otterness, ADOT				X/A	X/A
Tom Foster, ADOT				X	X
Bill Wang, ADOT				X/A	X/A
Bob Wortman, U of A				X/A	X/A
Debra Brisk, ADOT				X	X
ADOT SMS Coordinator	X	X	X	X	X
Other Participants					
Frank McCullagh, ADOT	A	A		A	A
Joe Breyer, Lee Engineering	A	A	A	A	A
Jim Lee, Lee Engineering	A			A	A
Sarath Joshua, Lee Engineering	A	A	A	A	A
Derek Calomeni, Lee Engineering	A	A	A	A	A

Exhibit 1 – Invitation Summary Table showing cross-section of disciplines and agencies invited to participate in the CSIP pilot study. X represents invitees. A represents attendees.

MEETING ON
LAW ENFORCEMENT INITIATIVES

FOR

HIGHWAY CORRIDOR SAFETY IMPROVEMENTS

JUNE 9, 1998

AGENDA

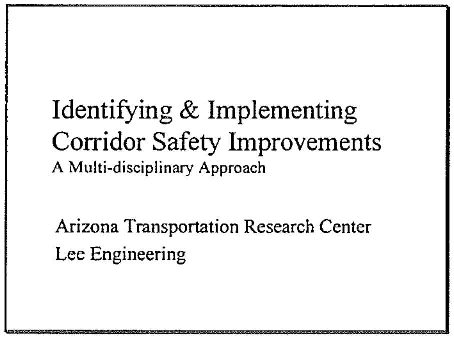
10:00 – 10:15 AM	Introductions	Joe Breyer Frank McCullagh
10:15 – 10:25 AM	Overview of Project Goals and Objectives	Joe Breyer Jim Lee
10:25 – 10:30 AM	Meeting Goals & Objectives	Sarath Joshua
10:30 – 10:35 AM	Ground Rules for the Meeting	Frank McCullagh
10:35 – 11:20 AM	GIS Tools for Safety Analysis	Joe Breyer
11:20 – 11:45 AM	Review of US 93 Corridor Safety Record	Sarath Joshua
11:45 – 12:00 Noon	BREAK	

WORKING LUNCH

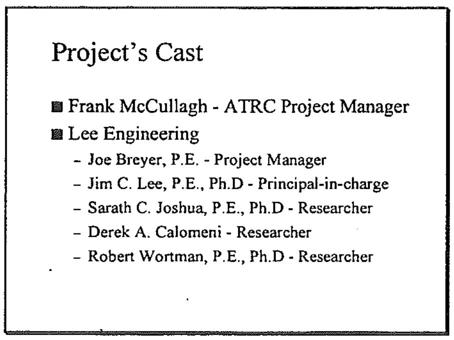
12:00 – 12:30 PM	Brainstorm Session on Corridor Safety Issues	Derek Calomeni Joe Breyer
12:30 – 12:50 PM	Rank Key Corridor Safety Issues	Derek Calomeni Joe Breyer
12:50 – 1:15 PM	Countermeasures Implemented Elsewhere	Sarath Joshua
1:15 – 1:45 PM	Identify Countermeasures for Corridor	Jim Lee Sarath Joshua
1:45 – 1:55 PM	Closing Remarks	Joe Breyer
1:55 – 2:00 PM	Evaluation of Meeting	Frank McCullagh

Exhibit 2– Typical planned meeting agenda for each of the four meetings of individual disciplines. Actual agenda was allowed to free form to the participants will in order to maximize support for the effort. Participants were anxious to air their "Gut" feelings early in the meeting. These issues were recorded as a basis and then fortified or debunked by subsequent discussions as the meeting progressed. The meetings often lasted 30 to 45 minutes past scheduled adjournment due to the concern and enthusiasm the participants held for the process.

Slide 1



Slide 2



Slide 3

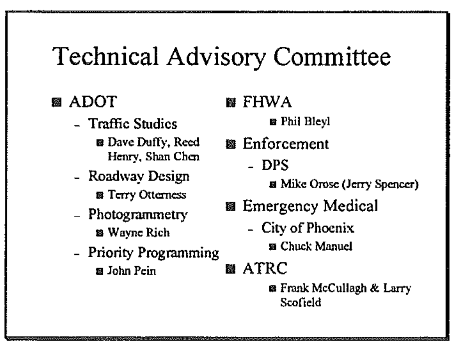


Exhibit 3 – The electronic slide presentation that introduced each of the 4E meetings introduced the players and goals of the meeting, pilot project, and overall CSIP. Slide 11 was used as the closing slide for each of the 4E meetings to gauge the worthiness of the process and safety analysis tools.

Slide 4

Law Enforcement Team
(09 June 1998)

- AZ DPS
  - Lt. John Tibbets
- ASU/AZ DPS
  - Dr. Denis Duffy
- FHWA
  - Phil Bleyl
- ATRC
  - Frank McCullagh
- Other Invitees
  - Governor's Office of Community & Highway Safety
  - Sheriffs Office

Slide 5

Education Team (11 June 1998)

- ASU/AZ DPS
  - Dr. Denis Duffy
- FHWA
  - Phil Bleyl
- ADOT
  - Bob Hall
- AAA Arizona
  - Cydney DeModica
- ATRC
  - Frank McCullagh
- Other Invitees
  - Governor's Office of Community & Highway Safety
  - National Safety Council, AZ Chapter
  - ADOT Community Relations

Slide 6

Emergency Medical Services Team (18 June 1998)

- DPS EMSCOM
  - Steve Powles
- Kingman Medical Ctr.
  - Ken McLaughlin
  - Susan Kern
- Wickenburg Police
  - Tom Evans
- River Medical Ambulance Service
  - Mike Caswell
- ADOT/Phoenix Fire
  - Chuck Manuel
- ADOT
  - Steve Owen
- FHWA
  - Phil Bleyl
- Other Invitees
  - Governor's Office of Community & Highway Safety

Exhibit 3 (Continued)

Slide 7

Engineering Team (23 June 1998)

- ADOT Traffic Studies
  - Dave Duffy
  - Reed Henry
- Regional Engineer
  - Bob LaJeunesse
- District Engineer
  - Jim Glasgow
  - Debra Brisk
- University of Arizona
  - Bob Wortman
- ADOT Roadway Design
  - Terry Otterness
- ADOT TTG
  - Steve Owen
- FHWA
  - Phil Bleyl
- Maintenance
  - Bill Wang
  - Tom Foster

Slide 8

Project Goals & Objectives

- As stated by the RFP: To develop procedures for identifying, defining, and implementing corridor safety improvement strategies
- As expressed by ADOT Traffic Studies (post-RFP and pre-award): Tools!
- Consensus TAC (post-award): Explore CSIP process as established in other states - form fit to Arizona parameters - prototype tools

Slide 9

Meeting Goals & Objectives

- Provide participants an understanding of the concept of the CSIP (Corridor Safety Improvement Program or Process)
- Discuss steps needed to develop a CSIP for Arizona
- Demonstrate analysis tools usable by participating agencies
- Establish understanding of multi-agency involvement and contacts for further coordination and communication of the program
- Identify corridor safety issues and potential countermeasures
- End results from meeting to be discussed at Workshop on July 1, 1998

Exhibit 3 (Continued)

Slide 10

Ground Rules

- Have high expectations for the group
- Focus on achieving the goals of this meeting
- Create an atmosphere in which all participants feel comfortable in participating
- Respect each other
- Give everyone the opportunity to speak, one at a time
- Don't use "killer" phrases or gestures
- Write down each idea exactly as it is generated
- Listen! Listen! Listen!
- Treat all as you would like to be treated

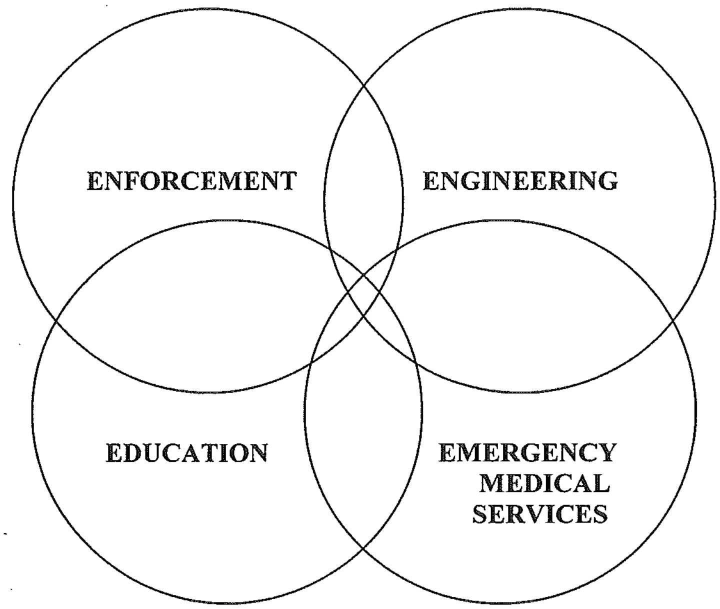
Slide 11

Closing Remarks

- CSIP Process - Worthy or not?
- Safety issue identification tools - Would you be interested in using them to prepare input for the overall process?
- Would you indicate your support of the process to encourage ADOT or GOHS to fund further development of the tools and a champion for the CSIP process?

Exhibit 3 (Continued)

CORRIDOR HIGHWAY SAFETY
IMPROVEMENT PROGRAM



Source: CSIP Presentation Material – Aida Berkowitz, FHWA Region 9, San Franciscio

Exhibit 4 – Nine-page handout to all pilot study participants summarizes the CSIP process in the form of overhead transparencies.

CORRIDOR APPROACH

- INTEGRATES:
  - ENGINEERING
  - ENFORCEMENT
  - EDUCATION
  - EMERGENCY MEDICAL SERVICES

- COMBINED AGENCY EFFORT

- ADDRESSED LONG SECTIONS OF ARTERIAL HIGHWAYS

- COMMUNITY INVOLVEMENT

Exhibit 4 (Continued)

ENFORCEMENT
TYPICAL IMPROVEMENTS

- SOBRIETY CHECK POINTS

- HIGH PROFILE SAFETY BELT WARNING AND ENFORCEMENT CAMPAIGNS

- ENFORCEMENT BLITZES DURING PEAK CRASH HOURS

- TARGETED SAFE WALKING CAMPAIGNS

- INCREASE/ADD TRUCK INSPECTIONS (MCSAP)

Exhibit 4 (Continued)

EDUCATION AND AWARENESS CAMPAIGN

- **KICK-OFF CAMPAIGN**
- **BUSINESS SPONSORED ANTI-IMPARED DRIVING AND SAFETY BELT PROGRAMS**
- **SAFETY BELT INCENTIVE PROGRAMS FOR CUSTOMERS AND EMPLOYEES**
- **TARGETED EDUCATION PROGRAMS IN SCHOOLS**
- **CORRIDOR BROCHURES**
- **USE OF BILLBOARDS**
- **NEWSPAPER ARTICLES AND RADIO COVERAGE OF DRIVER PERFORMANCE PROBLEMS**

Exhibit 4 (Continued)

ENFORCEMENT – EDUCATION AND AWARENESS CAMPAIGNS

- COORDINATED AMONG THE JURISDICTIONS
- TARGETED TO THE DRIVER PERFORMANCE CONCERNS
- INVOLVES MEDIA
- POLITICAL AND COMMUNITY SUPPORT

Exhibit 4 (Continued)

ENGINEERING
TYPICAL IMPROVEMENTS

- IMPROVED DELINEATION OF A ROADWAY

- MINOR ENGINEERING IMPROVEMENTS
  - CHANNELIZATION
  - ACCESS CONTROL
  - PAVEMENT SURFACE

- OPTIMIZE SIGNAL TIMING AND PHASING

- CLEAR ROADSIDE PROGRAM

- UPGRADE SIGNS

- ESTABLISH MCSAP (TRUCKS) INSPECTION SITES

Exhibit 4 (Continued)

EMERGENCY MEDICAL SERVICES
TYPICAL IMPROVEMENTS

- **UPGRADE COMMUNICATION SYSTEMS**
- **TRAINING AND EQUIPMENT UPGRADES**
- **USE OF TRAUMA CENTERS**
- **EMERGENCY RESPONSE PLANS**

Exhibit 4 (Continued)

LEAD AGENCY RESPONSIBILITIES

- DEVELOP WORK PLAN
  - ASSESS RESOURCES
  - MEET WITH VARIOUS AGENCIES
- IDENTIFY/SELECT CORRIDORS
- ESTALISH/MEET WITH MULTI-DISCIPLINARY SAFETY TEAM
- PROVIDE TECHNICAL ASSISTANCE
- EVALUATION

Exhibit 4 (Continued)

MULTI-DISCIPLINARY SAFETY TEAM

- STUDY CORRIDOR
  - DEVELOP ACTION PLAN
  - CONDUCT STRATEGY WORK SESSSIONS

- OBTAIN COMMUNITY SUPPORT

- IMPLEMENT INITIATIVES

- EVALUATION

Exhibit 4 (Continued)

APPENDIX B

US 93 – CRASH DATA

US 93 CORRIDOR CRASH HISTORY 1994-1996

1. Crashes by Day of Week (Table)
2. Crashes by Day of Week (Chart)
3. Crashes by Time of Day (Sat & Sun)
4. Restraint Usage & Crash Severity
5. Driver Physical Condition & Crash Severity
6. Driving Violation & Crash Severity
7. Collision Manner & Crash Severity
8. Collision Manner & Daylight/Darkness Conditions
9. Vehicle Type & Crash Severity
10. Vehicle Action & Crash Severity
11. Type of Collision(Object) & Crash Severity
12. Intersection/Driveway Related Crashes

Exhibit 5– Thirteen-page handout to all pilot study participants summarizes some points of view that were developed by tabular methods from the ALISS database by the researchers. These charts do not represent a prescribed set of analyses for all corridors. Instead, they are a selected set of analyses that can be a starting point for developing a set of pre-programmed queries. In a real CSIP, tabular tools such as these should be tied to graphical tools which lend a better perceptibility to the reviewing audience. Furthermore, the analysis tools should be set up to respond well to ad hoc queries, so that the participants can investigate their own hunches with relative ease.

US 93 Corridor
Crashes by Day of the Week

		SEVERITY					
YEAR	DAY OF WEEK	Fatality	Injury	PDO	Grand Total	US93	Statewide
	Sunday		8	11	19	14%	10%
	Monday		6	17	23	**17%**	**14%**
	Tuesday		7	10	17	13%	14%
1994	Wednesday	1	6	9	16	12%	5%
	Thursday		6	7	13	10%	15%
	Friday	3	12	13	28	21%	18%
	Saturday		11	9	20	15%	14%
1994 Total		4	56	76	136		
	Sunday		8	10	18	10%	10%
	Monday	1	15	23	39	**22%**	**14%**
	Tuesday	1	10	15	26	15%	15%
1995	Wednesday		11	15	26	15%	15%
	Thursday		2	12	14	8%	15%
	Friday		10	17	27	15%	18%
	Saturday		11	14	25	14%	13%
1995 Total		2	67	106	175		
	Sunday	2	10	10	22	16%	9%
	Monday		8	18	26	**19%**	**14%**
	Tuesday	1	7	13	21	15%	15%
1996	Wednesday		3	16	19	14%	15%
	Thursday		6	9	15	11%	15%
	Friday		6	10	16	12%	18%
	Saturday	2	4	14	20	14%	13%
1996 Total		5	44	90	139		
Grand Total		11	167	272	450		

Exhibit 5 (Continued)

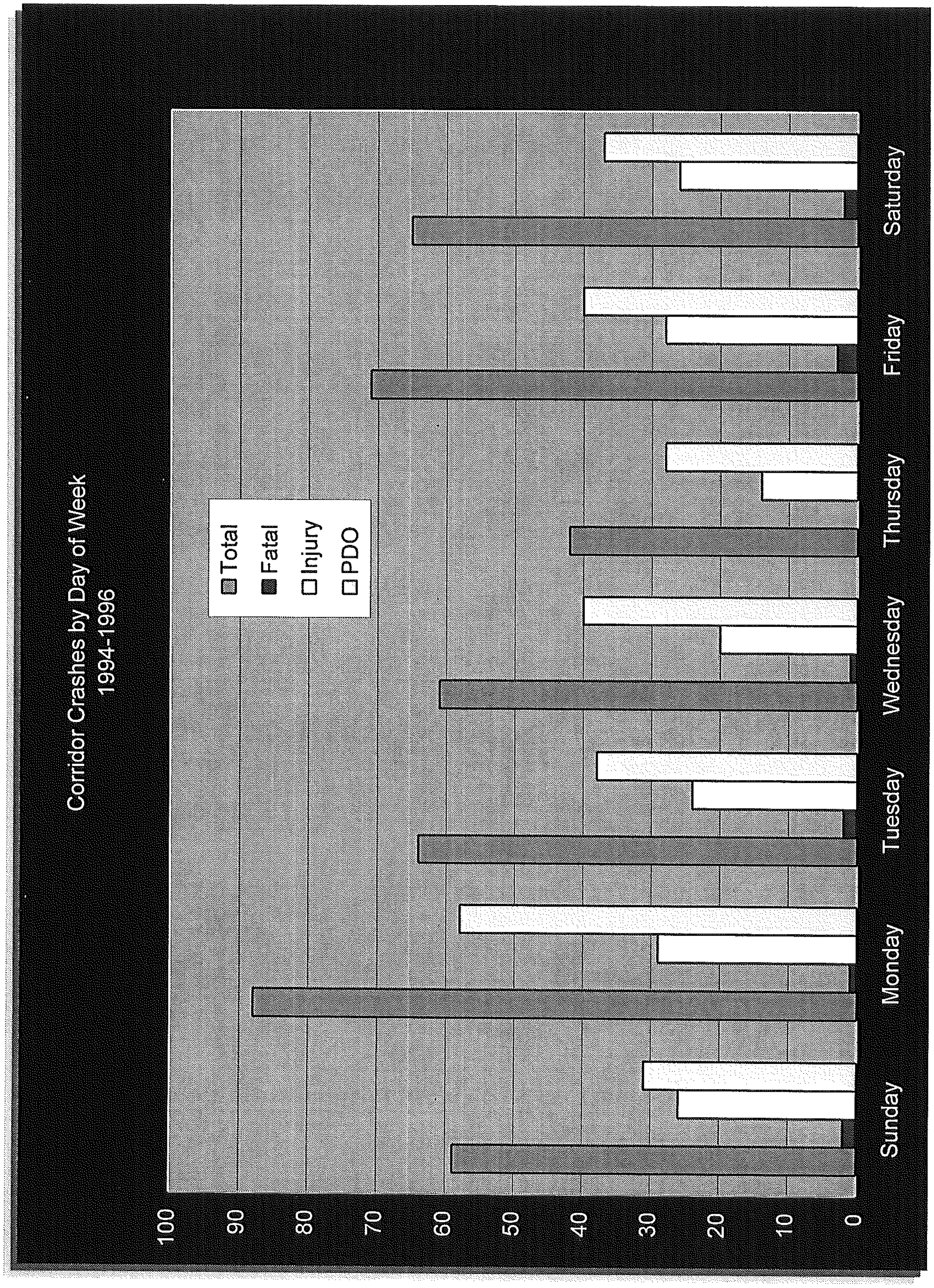


Exhibit 5 (Continued)

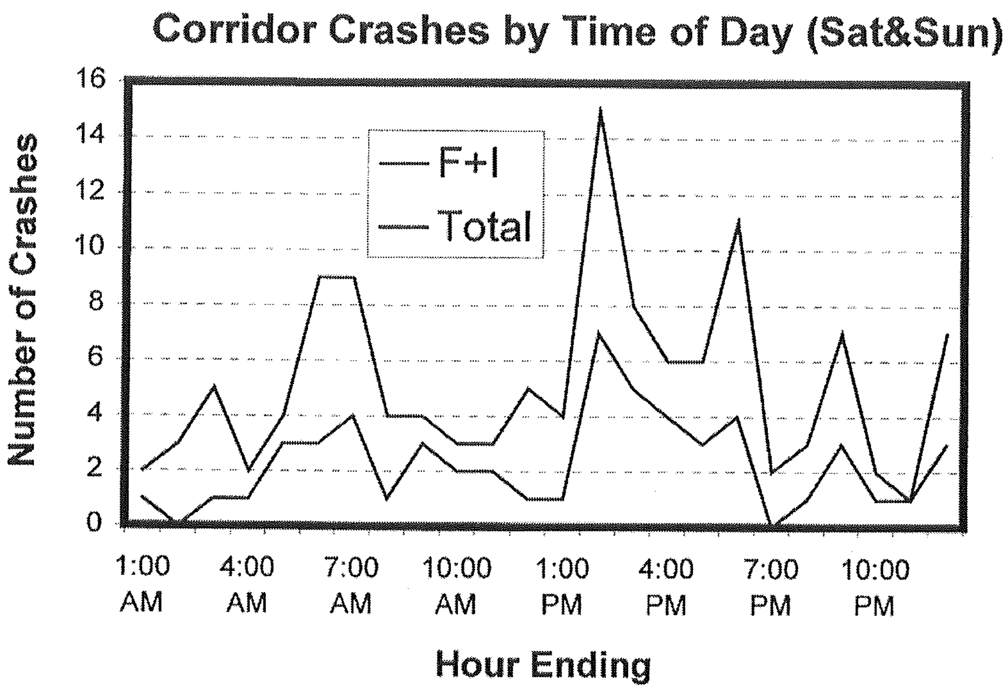


Exhibit 5 (Continued)

Restraint Usage & Crash Severity

Year	Restraint	Severity			
		Fatality	Injury	PDO	Grand Total
	Airbag Deployed		5	1	6
	Lap/Shoulder Belt	4	48	77	129
1994	LapBelt	1	7	7	15
	None Used	3	15	5	23
	Not Reported		2	9	11
1994 Total		8	77	99	184
	Airbag Deployed	1	8	3	12
	Lap/Shoulder Belt	2	68	114	184
1995	LapBelt		5	10	15
	None Used		10	10	20
	Not Reported		4	11	15
1995 Total		3	95	148	246
	Airbag Deployed		7	1	8
	Lap/Shoulder Belt		44	90	134
1996	LapBelt	2	4	4	10
	None Used	4	5	5	14
	Not Reported	1	3	11	15
	Protective Helmet		1		1
1996 Total		7	64	111	182
Grand Total		18	236	358	612

Exhibit 5 (Continued)

Driver Physical Condition by Severity

YEAR	PHYSICAL CONDITION	SEVERITY					
		Fatality	Injury	PDO	Grand Total	US 93	Statewide
	Been Drinking	1	7	2	10	5%	3.9%
	Fatigued		1		1	1%	0.9%
1994	Illness		1	1	2	1%	0.2%
	No Defects	6	51	78	135	73%	87.0%
	Not Reported	1	5	13	19	10%	7.6%
	Other Defects		12	5	17	9%	0.3%
1994 Total		8	77	99	184		
	Been Drinking		5	6	11	4%	3.8%
	Illness			1	1	0%	0.1%
1995	No Defects	2	76	119	197	80%	87.0%
	Not Reported	1	2	11	14	6%	8.0%
	Other Defects		13	11	24	10%	0.3%
1995 Total		3	96	148	247		
	Been Drinking	2	8	2	12	7%	3.7%
	Illness			2	2	1%	0.1%
1996	No Defects	2	45	92	139	76%	87.4%
	Not Reported	2	3	6	11	6%	7.6%
	Other Defects	1	8	9	18	10%	0.3%
1996 Total		7	64	111	182		
Grand Total		18	237	358	613		

Exhibit 5 (Continued)

Violation & Crash Severity

YEAR	VIOLATION	SEVERITY			
		Fatality	Injury	PDO	Grand Total
1994	Following Too Closely		2	2	4
	Failed to Yield ROW			1	1
	Inattention		1	3	4
	None	4	27	45	76
	Other		4	5	9
	Other Unsafe Passing	1	2	2	5
	Passing In No Pass Zone			3	3
	Too Fast for Conditions	1	35	25	61
	Unknown		3	9	12
	Unlawful Speed		1	1	2
	Wrong Way	2	2	3	7
1994 Total		8	77	99	184
1995	Following Too Closely		2	2	4
	Failed to Yield ROW		1	2	3
	ImproprTrn		1		1
	Inattention		4	13	17
	None	1	33	62	96
	Other		2	6	8
	Other Unsafe Passing		1		1
	Too Fast for Conditions	1	41	36	78
	Unknown		5	17	22
	Unlawful Speed	1	2	3	6
	Unsafe Lane Change			2	2
	Wrong Way		4	5	9
1995 Total		3	96	148	247
1996	Following Too Closely		3		3
	Failed to Yield ROW			1	1
	Inattention		3	5	8
	Faulty Equipment			1	1
	None	2	25	59	86
	Other		2	4	6
	Other Unsafe Passing		2	3	5
	Passing In No Pass Zone		2		2
	Too Fast for Conditions	2	20	25	47
	Unknown	1	1	4	6
	Unlawful Speed		3	3	6
	Unsafe Lane Change			1	1
	Wrong Way	2	3	5	10
1996 Total		7	64	111	182
Grand Total		18	237	358	613

Exhibit 5 (Continued)

Collision Manner & Crash Severity

Year	COLLISION MANNER	SEVERITY			TOTAL	MultiVeh US93	MultiVeh Statewide
		Fatality	Injury	PDO			
1994	Head On	2	9		11	12%	
	One Vehicle	1	39	55	95		
	Other		2	8	10	11%	
	Rear End		11	22	33	37%	
	Side Swipe Opp. Dir	5	9	10	24	27%	
	Side Swipe Same Dir.		7	4	11	12%	
1994 Total		8	77	99	184		
1995	Angle		2	2	4	3%	
	Backing			6	6	5%	
	Head On		2	2	4	3%	1.00%
	Left Turn		2	2	4	3%	
	NC not Mc		2		2	2%	
	One Vehicle	1	43	69	113		
	Other	2	4	17	23	17%	
	Rear End		32	23	55	41%	42%
	Side Swipe Opp. Dir.		6	18	24	18%	1%
	Side Swipe Same Dir.		2	9	11	8%	12%
1995 Total		3	95	148	246		
1996	Angle			2	2	2%	
	Head On	4	7		11	14%	0.64%
	NC Not mc			3	3	4%	
	One Vehicle	3	28	70	101		
	Other		5	6	11	14%	
	Rear End		12	10	22	27%	42%
	Side Swipe Opp. Dir.		8	12	20	25%	1%
	Side Swipe same Dir.		4	8	12	15%	12%
1996 Total		7	64	111	182		
Grand Total		18	236	358	612		

Exhibit 5 (Continued)

Collision Manner & Daylight/Darkness

YEAR	COLLISION MANNER	LIGHT			Grand Total
		Darkness	Dawn/Dusk	Daylight	
1994	Head On	9		2	11
	One Vehicle	38	5	52	95
	Other	2		8	10
	Rear End	4		29	33
	SswipeOpst	8	2	14	24
	SswipeSame	2		9	11
1994 Total		63	7	114	184
1995	Angle		2	2	4
	Backing			6	6
	Head On			4	4
	Left Turn			4	4
	NC not mc	2			2
	One Vehicle	57	5	51	113
	Other	10		13	23
	Rear End	6		49	55
	SswipeOpst	12	2	10	24
	SSwipeSame	5		6	11
1995 Total		92	9	145	246
1996	Angle		2		2
	Head On	9		2	11
	NC not mc			3	3
	One Vehicle	53	6	42	101
	Other	4		7	11
	Rear End	2		20	22
	SSwipeOpst	12		8	20
	SSwipeSame	4		8	12
1996 Total		84	8	90	182
Grand Total		239	24	349	612

Exhibit 5 (Continued)

Vehicle Type & Crash Severity

YEAR	BODY STYLE	SEVERITY			Grand Total
		Fatality	Injury	PDO	
1994	Commercial Bus	1			1
	Motor Home or House Car		4	1	5
	Motorcycle (two or three wheel)		2		2
	Not Reported		1		1
	Other Truck Combination		1	1	2
	Other Vehicle			1	1
	Passenger Car, regular	5	31	52	88
	Pick-Up Truck		23	26	49
	Pick-Up with Camper		2		2
	RV (all wheel drive, dune buggy, etc)		2	2	4
	Truck Tractor and Semi-Trailer	2	11	16	29
1994 Total		8	77	99	184
1995	Commercial Bus			2	2
	Motor Home or House Car			1	1
	Not Reported			1	1
	Other Truck Combination		5	11	16
	Passenger Car, regular	3	51	71	125
	Pick-Up Truck		23	29	52
	Pick-Up with Camper		2	3	5
	RV (all wheel drive, dune buggy, etc)		2	1	3
	Truck Tractor and Semi-Trailer		12	28	40
	Truck Tractor Only			1	1
1995 Total		3	95	148	246
1996	Commercial Bus	1	1	2	4
	Motor Home or House Car			5	5
	Motorcycle (two or three wheel)		1	1	2
	Not Reported		1	1	2
	Other Truck Combination	1	1	7	9
	Passenger Car, regular	2	33	46	81
	Pick-Up Truck	2	16	24	42
	RV (all wheel drive, dune buggy, etc)	1	1		2
	Truck Tractor and Semi-Trailer		10	24	35
1996 Total		7	64	111	182
Grand Total		18	236	358	612

Exhibit 7 (Continued)

US 93 Corridor
Vehicle Action & Crash Severity

		SEVERITY			
YEAR	VEHICLE ACTION	Fatality	Injury	PDO	Grand Total
1994	Avoiding Vehicle or Objects		3	10	13
	Changing Lanes			1	1
	Making Left Turn			1	1
	Overtaking/Passing	2	8	10	20
	Other	1		1	2
	Slowing inTrafficway		3	7	10
	Stopped in Trafficway		4	4	8
	Going Straight Ahead	5	59	61	125
	Unknown			4	4
1994 Total		8	77	99	184
1995	Avoiding Vehicle or Objects		10	9	19
	Backing			3	3
	Changing Lanes			1	1
	EnterPkPos			1	1
	Leaving Driveway			1	1
	Making Left Turn		2	4	6
	Making Right Turn		1	1	2
	Overtaking/Passing		5	9	14
	Other		2	1	3
	Slowing inTrafficway		8	9	17
	Stopped in Trafficway		15	15	30
	Going Straight Ahead	3	53	92	148
	Unknown			2	2
1995 Total		3	96	148	247
1996	Avoiding Vehicle or Objects		7	9	16
	Changing Lanes			2	2
	Entering Driveway		1		1
	Leaving Driveway			1	1
	Making Right Turn			2	2
	Overtaking/Passing		6	5	11
	Other		2	1	3
	Slowing inTrafficway	1	4	2	7
	Stopped in Trafficway		3	4	7
	Going Straight Ahead	6	41	84	131
	Unknown			1	1
1996 Total		7	64	111	182
Grand Total		18	237	358	613

Exhibit 5 (Continued)

TYPE OF COLLISION & SEVERITY							
COLLISION TYPE/OBJECT	**YEAR**						
	1994	**1995**	**1996**	**Grand Total**	**Fatal**	**Injury**	**PDO**
All Other Non-Collision	8	6	6	20		7	13
w/Animal Livestock	6	3	3	12		3	9
w/Animal Pets		1	1	2			2
Boulder	2	4	5	11		7	4
Bridge Culvert	2	5	1	8		6	2
Curb	1	1	1	3			3
Fence	1	3		4		2	2
CfllTreStn		1	1	2			2
Guard Rail	6	5	4	15		6	9
CobjDrpVeh	4	4	6	14			14
Other Fixed Object	27	29	22	78		35	43
Other Motor Vehicle	40	60	37	137	6	54	77
Other Non Fixed Object		1		1			1
pedal cyclist		1		1		1	
Special Devices			1	1			1
Traffic Barrier	1			1			1
Traffic Sign		7	4	11		4	7
Tree	9	9	8	26	1	6	19
Wild Game	6	8	13	27		2	25
Object Fell From Vehicle		1	1	2			2
Object Thrown			1	1			1
Occupant Fall	1			1		1	
Rollover	18	20	17	55	4	31	20
Vehicle Breakage	3	2	1	6		2	4
Vehicle Fire	1	4	6	11			11
Grand Total	136	175	139	450	11	167	272

Exhibit 5 (Continued)

US 93 Intersection/Driveway Related Accidents

	Intersection/Driveway Related			Total		
	F	Injury	PDO	F	I	PDO
1994	0	3	4	4	56	76
1995	0	2	5	2	67	106
1996	0	1	2	5	44	90

Exhibit 5 (Continued)

Year	Day	Accd Time	Number of Vehicles	Number of Persons	Fatals	Incapacit.	Non-incap.	Possible Injury	None	Fatals/Age	AMBULANCE Time to Call (minutes)	AMBULANCE Time from Call to Arrival (minutes)	AMBULANCE Total Time (minutes)	Milepost		
															1991	
	Thur	22:40	2	4	1	2	1			25	1	12	13	191		
	Tues	10:48	2	4	1	2	1			25	12	30	42	166	Mean	55
	Wed	14:30	2	4	1	2	1			69	25	65	90	148	SD	21
1991	Wed	20:35	2	4	1	1	1		1	45	11	59	70	119	Minimum	13
	Sun	1:30	1	1	1					26	38	26	64	146	Maximum	90
	Sat	9:20	1	4	2		2			41	11	41	52	148		
										64	11	41	52	148		
	Thur	• 9:15	2	4	2				2	19	5	50	55	100		
										47	5	50	55	100		
															1992	
	Sat	2:30	2	3	2				1	20	40	25	65	146		
										25	40	25	65	146		
	Mon	20:10	1	1	1					32	13	8	21	120	Mean	52
	Fri	17:40	1	1	1					42	20	23	43	162	SD	14
1992	Sat	14:00	2	4	2		2			44	10	33	43	162	Minimum	21
										44	10	33	43	112	Maximum	70
	Fri	12l00	1	2	1		1			48	11	34	45	111		
	Sun	20:00	3	6	1	3	1		1	25	31	26	57	97		
	Wed	6:00	1	1	1					45	3	57	60	159		
	Tues	1:50	1	1	1					36	23	47	70	142		
	Sun	9:00	3	**8**		**6**			1	48	20	40	.60	157		
															1993	
	Mon	9:15	1	2	2					80	12	30	42	108	Mean	59
1993										85	12	30	42	108	SD	29
	Sat	22:00	1	1	1					58	53	40	93	154	Minimum	42
															Maximum	93
															1994	
	Wed	22:03	2	**57**			**37**			33	25	29	54	174		
1994										6	25	29	54	174	Mean	58
	Fri	3:30	2	2	1				1	41	16	59	75	136	SD	20
	Fri	13:55	1	2	1	1				47	19	59	78	137	Minimum	28
	Fri	15:30	3	5	1	3		1	1	38	5	23	28	175	Maximum	78
															1995	
1995	Mon	12:40	2	3	1	1	1			78	10	65	75	154	Mean	49
	Tue	17:15	1	4	1	2	1			45	10	12	22	186		
															1996	
	Sun	6:15	2	3	1	1	1			34	15	45	60	113		
	Sat	23:20	2	**33**			**10**	1		31	26	8	34	177	Mean	48
1996	Tues	5:50	1	2	1	1				38	8	46	54	146	SD	22
	Sat	23:30	1	**9**		**5**	**2**			29	20	45	65	164	Minimum	10
										16	20	45	65	164	Maximum	65
	Sun	7:55	1	1	1					53	10	0	10			
															1997	
#	Sat	2:15	2	3	1	1			1	59	21	59	80	134		
Total					9	11	15									
Total(Fri,Sat&Sun)					21	20	19									

Exhibit 6 – A two-page handout that was supplied to the EMS task force in addition to Exhibit 5. The information depicts a tabular and graphical picture of response times to crashes that resulted in a fatality along the study corridor.

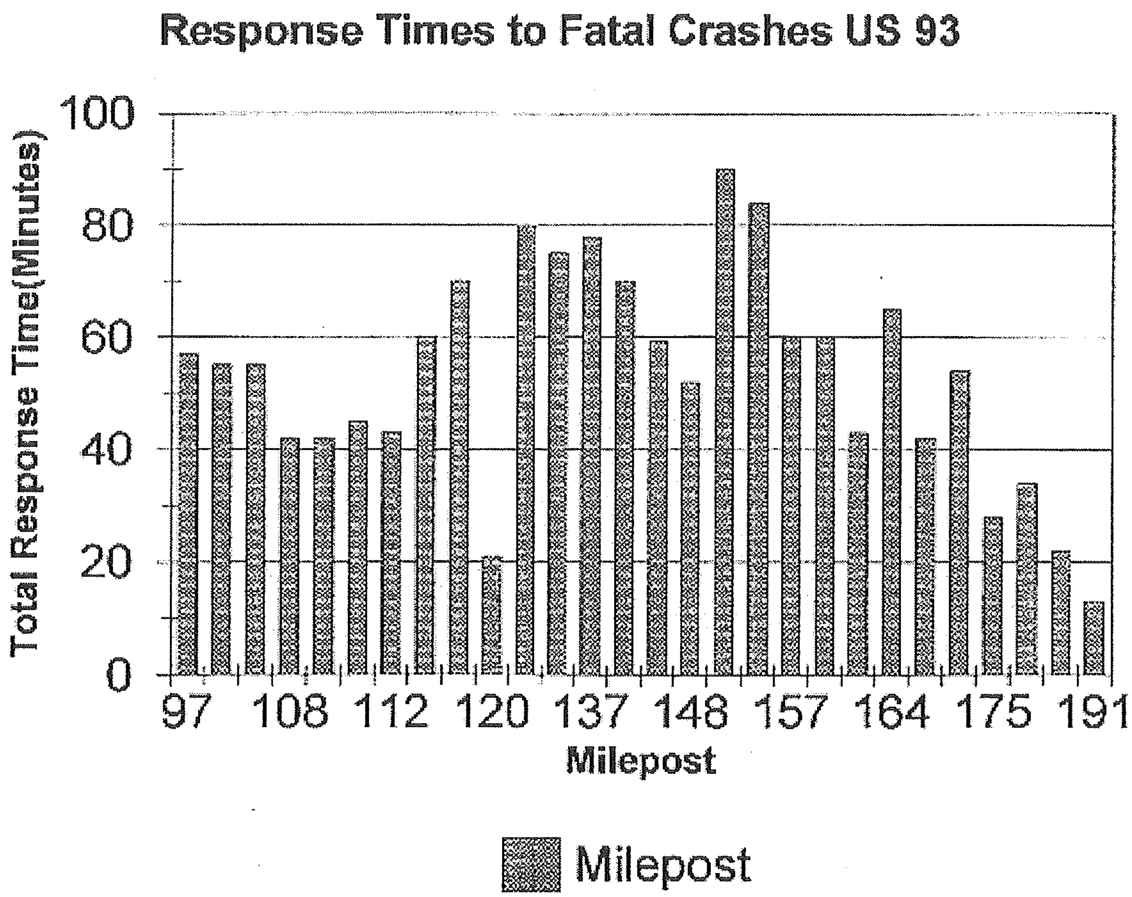


Exhibit 6 (Continued)